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E7.4-10.718
CR-139548

FINAL REPORT

to the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Title: Extent of Cyclic and Changing Ecological Phenomena and Semipermanent Vegetation-Ecosystem Interface

Subtitle: Ecological Applications of ERTS-A Imagery

Proposal No. SR No. 162-II

GSFC ID No. UN 598, Contract No. NAS 5-21882

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INTRODUCTION

General

This report constitutes the Final Report of NASA Contract No. NAS 5-21882 "Extent of Cyclic and Changing Ecological Phenomena and Semi-permanent Vegetation-Ecosystem Interfaces: Ecological Applications of ERTS-A Imagery" for the entire period March 1972 - October 1973 plus extension.

The ERTS-A satellite image output, widely and easily available to the public, contains enormous amounts of information of many kinds. Some of this information society already has acquired and some is doubtless contained in the imagery but is difficult to interpret. However, much information is available about earth surface and subsurface characteristics which is not yet known but which should be quantified and sequentially monitored.

Objectives

This project has sought qualitative and quantitative answers to four questions about East Tennessee-Western North Carolina vegetation phenomena:

1) Can winter leaf chlorosis in evergreens seen on the ground here be seen on imagery and is it bedrock related?

2) Can vegetation phenologic change be used in spring to see and/or map certain kinds of hardwood stands?

3) Can catastrophic results of attacks of the balsam wooly aphid on Fraser fir be seen in high mountain spruce-fir stands?

4) Can various vegetation-ecosystem interfaces be seen/mapped from routine imagery?

Imagery proved inappropriate to adequately attack the first three objectives. We consequently focused on the fourth objective.

We have examined landscape features, especially vegetation boundaries in three physiographic-ecosystem areas: 1) Wilson Mountain in the Cumberland Mountains, Morgan County, Tennessee; 2) various sites including the Oak Ridge area, Mascot, and Chilhowee Mountain in the Valley and Ridge area of Anderson, Knox and Blount Counties, Tennessee; and 3) the state line ridge in the Great Smoky Mountains National Park, Sevier and Blount Counties, Tennessee, and Haywood and Swain Counties of western North Carolina, and Mount Mitchell, Yancey County, North Carolina.

Acknowledgements

This research has had, in addition to that from NASA, support from the Department of Botany and the Graduate Program in Ecology, University of Tennessee. The Image Analysis Group headed by Dr. Robert Bodenheimer has been invaluable. An underflight was obtained using University aircraft and flight personnel. Advice has been sought and received from other University ERTS projects headed by Dr. John Rehder and Dr. Larry Parks.

Graduate students helping on the project were: T.W. Taylor, B.F. Clark, R. T. Schnabel, C.R. Hinkle. Undergraduate and other assistance was received from Ron Kimball and Ron Masters.

THE STUDY AREA

General

This region is one of great topographic, climatic and edaphic diversity. Included here is part of the Blue Ridge, Ridge and Valley, and Appalachian Plateaus physiographic provinces (Fenneman, 1938). Topographic extremes are great, but more important, a high proportion of the landscape is dissected into relatively small topographic units, usually characterized by steep slopes throughout, or on the margins. Hammond (1966) characterizes the region as one of low mountains to open low mountains and open hills, with gentle slopes either on the lowland or upland. Falling within the Caf, and Cb climates or Köppen (Trewartha, 1943), climates of the lowlands are temperate, humid, and precipitation is well distributed throughout the year, though spring and fall deficits are typical. Mid-elevation climates, 4000-5000 feet, are similar to those of the eastern Lake States and New England. High elevation climates are most closely approached by low elevation climates of Maine and the Canadian Maritime provinces (Shanks, 1954). Within each of the three climatic bands precipitation and temperature are strongly influenced by the interaction of air flow (including cold air drainage) and topography (Shanks and Norris, 1950; Tennessee Valley Authority, 1955). In a small Appalachian plateau valley some miles northwest of the presently defined Southern Appalachians, the frost free season of two small microclimates differed by an average of 89 days during a five year study. The cold air drainage sink (frost pocket) aad a 125 day frost free season, the cove head of the steep-walled, sheltered valley had a 214 day frost free season (Wolfe, Wareham and Scofield, 1949).

The macro and micro climatic diversity is equalled by that of the soils. They are chiefly of the orders Inceptisol, and Ultisol--some Alfisol and Spodosol soils occur (U.S. Dept. Interior, 1970). These soils are residual-colluvial and alluvial, and are derived from largely Paleozoic and Pre-Cambrian bedrocks which have been exposed to weathering probably since the late Paleozoic time (Fenneman, 1938). Many of the sediments which give rise to the parent materials of soils are siliceous. When eroding the materials often form rough landscapes but when weathering it yields little clay capable of forming high cation exchange capacities and high moisture holding capacities. Many of the soils are stony, sandy, acid, infertile and have shallow profiles. Only about half of the land is in farms of which about 44 percent is farm forest (Proctor and White, 1962). Much of the non-farm land is also forested, in large public and private blocks held chiefly for extractive industries and forestry (Proctor and White, 1962; Tennessee Valley Authority, 1961). In the Tennessee Valley, for example, about 58 percent of the total area was in forest in 1960 (Tennessee Valley Authority, 1961). Through many of the past decades, the forest area has been increasing, when in the 1960's, the trend of return of land to a forest classification peaked (Duerr, 1951). The results from the most recent survey, in 1970, indicate a 1.9 percent decrease in commercial forest land area (Hedlund and Earles, 1971). Certain counties may be as much as 87 percent forested (Tennessee Valley Authority, 1973). More significant, however, is the findings of a recent survey, 1967 data, which indicates that in eastern Tennessee about three-fourths of the forest land and about one-third to one-half of all land is placed in (6e, s; 7e, s) classes which are unsuited for agriculture by reason of erosion or wetness hazard, or soil shallowness

(Tennessee Conservation Needs Inventory, 1971). While these lands are also in the lower productivity classes their forest productivity rates are imperfectly known although county-size area rates may vary by at least as much as 1:1.5 (DeSelm et al., 1971). The maximum differences between productivity rates are those between the extensive, dense, humid highly productive "unmanaged" forests of the Great Smoky Mountains and the "managed" oak forest of the surface of the Cumberland Plateau. Biological, climatic and soils differences doubtless account for part of the difference beyond human "management"(DeSelm et al., 1971).

While part of the land is used for crops and pastures, the forest landscape is used for wood products, coal, water, and water power production, as well as for recreation and aesthetics. It serves as a gene-resource pool which we will doubtless exploit for plants which can produce fibers and organic chemicals needed by society in the future--but which present technology does not require. It should be noted that the area is used for recreation and aesthetics by people of all states; witness the popularity of the Great Smoky Mountains National Park. It should also be noted that much of the coal extracted by both strip and deep mining is exported from this area and that part of the electric power developed is exported. About half of the coal mined in the United States is mined in the nearby states (U.S. Department of Commerce, 1971).

While certain parts, as national parks and forests of the area, are changing only slowly, other areas are changing rapidly. The most radically changing of these are areas being strip-mined. This form of devastation is occurring at the rate of about 100 square miles per year in the United States.

The Need for Resource Monitoring

A method of monitoring these and other changes as well as areal extent and quality of natural resources is required. The personal income of the Southern Appalachian people is low--the states rank 34th through 48th in income rank among the fifty; 600 to 1100 dollars per year below the national average (U.S. Department of Commerce, 1971). Resource assessment and monitoring is presently accomplished by a variety of state, regional and federal agencies such as state geological and soil surveys and conservation departments, the Tennessee Valley Authority, Appalachian Regional Commission, U.S. Forest Service, U.S. Soil Conservation Service, National Park Service and others. Reported are standing timber, timber growth, mineral resources, and wildlife population numbers. The first two are reported each decade by the Forest Service, or periodically by the Tennessee Valley Authority; mineral extractions are reported annually (Mineral Yearbooks) but potentials are reported only as private exploration groups make findings known. Wildlife populations are reported annually, before or after the season when they are hunted. Generalized information on mineral deposits (U.S. Geological Survey and Bureau of Mines, 1968), details of bedrock (Rodgers, 1953), hydrologic properties of landscapes (McMasters and Hubbard, 1970), and general vegetation (Tennessee Valley Authority, 1941) exist at small scales. However, recent studies in Tennessee have revealed dozens of previously undescribed vegetation types--these chiefly dominated by trees but containing hundreds of plant species (Cabrera, 1969; DeSelm, et al., 1969; Hoffman, 1964; Martin, 1971; Safley, 1970). Moreover, the status of the soil survey, while highly developed technically, is incomplete for the area. In the Tennessee area, for example among 37 counties, 17 are without surveys, 15 counties have surveys 15 to 36 years old and only seven counties have modern, post-1957 surveys. Moreover, most of the maps apply to the agricultural land area whereas rough or mountainous lands are treated only superficially.

It is possible that the states concerned here could establish a program of landscape survey and monitoring individually or collectively; but the scope and funds required make the likelihood of success greater if a centralized group were organized. Both a research group and a management group model is required. Part of the first already exists in the California vegetation-soil survey which has mapped millions of acres of wildland in the more rugged areas of that state (Wieslander and Storie, 1952). An integral part of this group must be the remote sensing arm as seen by the NASA programs, involving high flying aircraft, and satellites as ERTS and/or Skylab. The management phase could be handled by some data collection-oriented body patterned after certain groups within the Agricultural Stabilization and Conservation Service, Forest Service, Tennessee Valley Authority, or Ecological Sciences Division at Oak Ridge National Laboratory.

METHODS

All imagery received was inspected visually for suspected vegetation interfaces by comparison with already available and especially prepared maps. Certain areas were compared with ASCS panchromatic photographs. Imagery within the NASA Mission 193 of 18 April, 1972, in upper East Tennessee was used as "ground" truth where possible. Inspection on the ground of certain critical areas was made by Task personnel.

The coincidence of proper atmospheric conditions (low cloud cover) and vegetation types in a phenologic condition exhibing interface contrast was seldom met. On those scenes in which it did seem to be met, the bulk 70mm chip of the most appropriate band was mounted on a 3x5 card with a window cut to expose the critical area and submitted to the Image Analysis Group for microdensitometer scanning (Bodenheimer and Green, 1971, 1972). Outputs from the scan was in the form of a printout, simulating the original image. The density range of the image appeared as a series of 15 symbols, ⌐ to @, with a density corresponding to the point scanned on the image. A 25 micron raster was used in scanning; this meant that one print-out point equalled about 1.6 acres (0.656 hectares) on the ground at the scale of 1:31,100.

Map truth interfaces were converted to printout scale using the Model SS Map-o-Graph and compared to the printout using especially prepared overlays.

RESULTS

General Study

All ERTS imagery was examined with the view to determine the extent that known land forms, geology, soils, land use and vegetation types could be seen. Imagery of 15 October, 1972, was of this quality: 1084-15431-band 7 (Fig. 1). Even at the scale of 1:1,000,000 (or smaller in Fig. 1) many topographic-physiographic features are visible:

1. Cumberland Mountain, Cumberland Mountain and Plateau escarpment.
2. Pine Mountain, overthrust block between 1 and 2; light grey areas are recently strip-mined lands.
3. Ridge and Valley Province.
4. Unaka, here Great Smoky, Mountains.
5. T.V.A. reservoirs.
6. Reservoirs and tributary streams.
7. Crest of Great Smoky Mountains showing spruce-fir vegetation.
8. Folded-faulted ridge-valley topography visible chiefly because of shadowed north slopes and forested ridges versus agricultural valleys.
9. Speckled dark-light grey pattern a consequence of forest versus agricultural use on rolling dolomitic gentle slope landscape.
10. Smoother textured, more uniformly used lands of the shale knobs.

Clouds are conspicuous between 4 and 5. Lower slopes are usually in cultivation and on this image the south slope has been warmed like the valley flat. The north slope is cooler and darker. Thus the ridges often look narrower than they are, the lower south slope and perhaps lower north slope of a low ridge, having densities similar to agricultural lands.

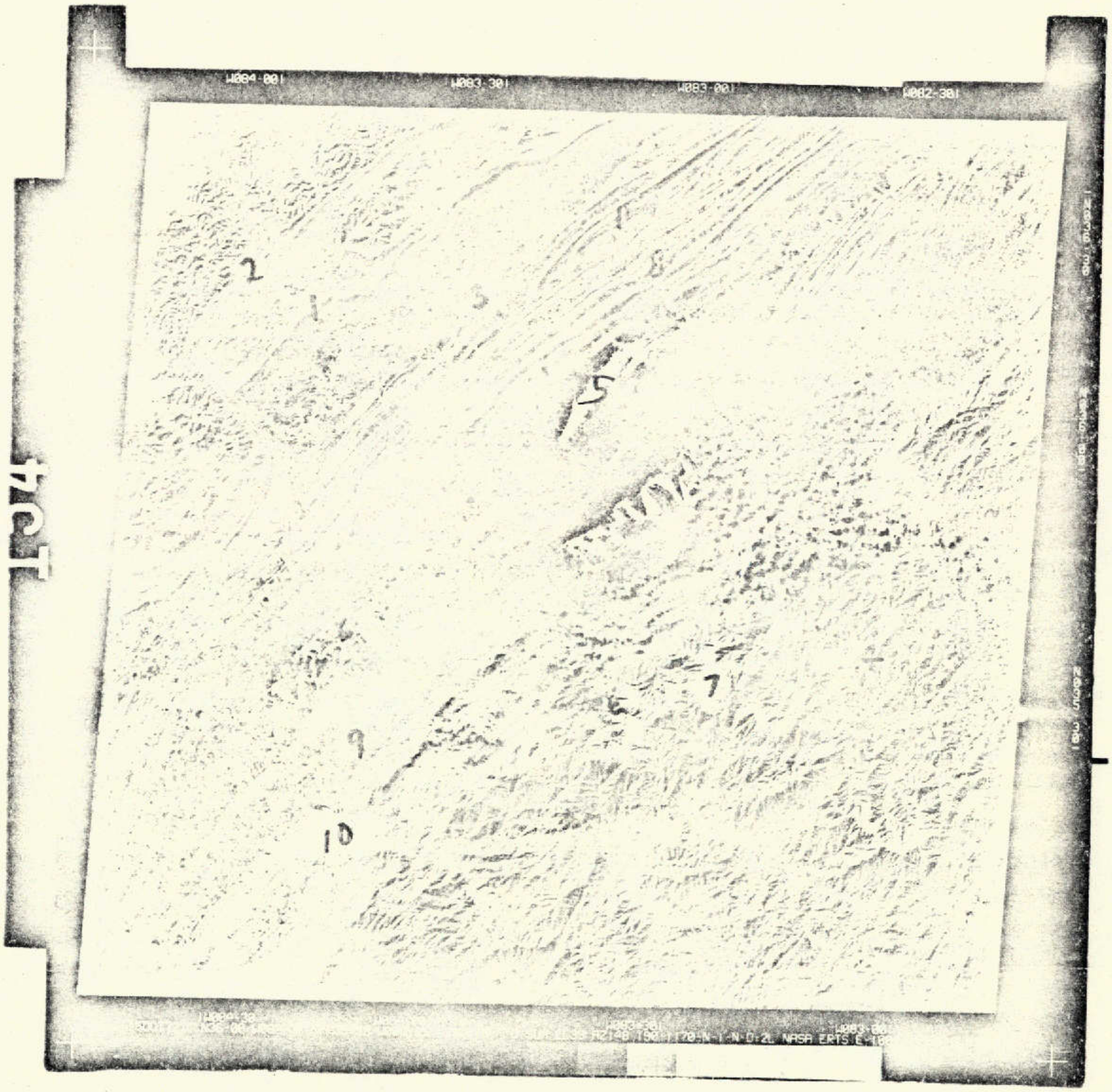

Figure 1. ERTS image of East Tennessee. Photographic print made directly from 70mm NASA ERTS-1 chip (1084-15431-6). Major physiographic features are visible.

Several geologic maps are available over parts of the area in scales from 1:250,000 (all of the area) to 1:24,000 (parts). Faulting and folding is evident on the image (Fig. 1). The Cumberland-Pine Mountain overthrust block has already been noted. The Short Mountain syncline (Fig. 1-11) appears. Most such features are in fact topography-soil caused land use boundaries.

Detailed Study

To make a more detailed study of such features on those noted above, parts of the 15 October, 1972, bulk panchromatic transparency was photographed and large prints made. These were mosaiced, a milar overlay was annotated, and the mosaic with overlay was photographed in sections and printed (Figures 2-6).

Features noted by quadrangle appear below, Fig. 2:

Big Ridge State Park Quadrangle

1) Longmire Bluff, 2) Bullrun Valley, 3) Bullrun Ridge, 4) Raccoon Valley, 5) Chestnut Ridge, 6) Flint Ridge.

Clinton Quadrangle

1) Blockhouse Valley, 2) Pine Ridge, 3) Wolf Valley, 4) Chestnut Ridge, 5) Flint Ridge, 6) Raccoon Valley, 7) Bullrun Ridge, 8) Industrial Area, 9) Brushy Valley with Bullrun Creek embayment to the south and the Clinch River-Melton Hill Reservoir to the west, 10) Copper Ridge, 11) Haw Ridge, 12) Oak Ridge City.

Powell Quadrangle

1) Clinch River, 2) Pine Ridge, 3) Wolf Valley, 4) Chestnut Ridge, 5) Flint Ridge, 6) Raccoon Valley, 7) Bullrun Ridge,

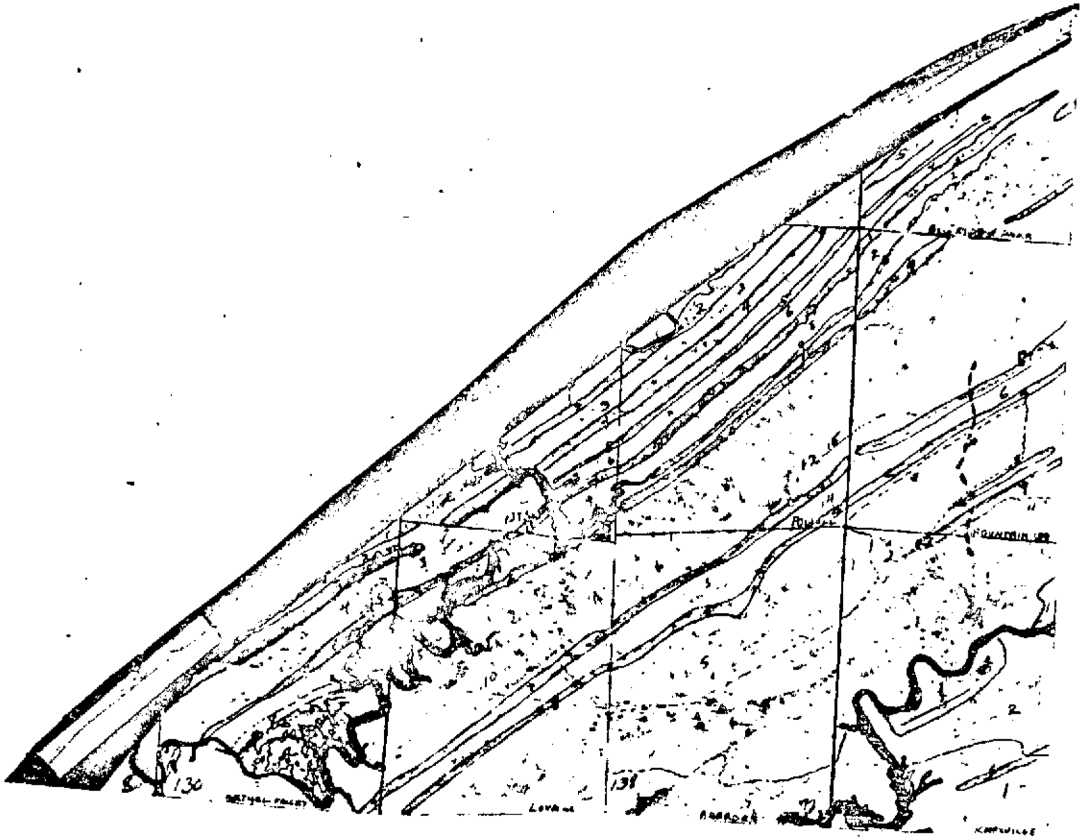

Figure 2. Area near Knoxville, Tennessee.
Photo derived from ERTS 1084-15431, band 7.

8) Bullrun Creek Valley, 9) unnamed ridge, 10) Brushy Valley, 11) Copper Ridge, 12) Beaver Valley, 13) Beaver Ridge, 14) Hinds Valley, 15) Blackoak Ridge, 16) Emory Road.

Fountain City Quadrangle

1) Bullrun Ridge, 2) Bullrun Creek valley, 3) bluff, 4) Copper Ridge, 5) Beaver Ridge, 6) Hinds Valley, 7) Blackoak Ridge, 8) unnamed ridge, 9) Sharp Road, 10) U.S. 441, 11) Knoxville dashed line.

Bethel Valley Quadrangle

1) Pine Ridge, 2) Bear Creek Valley, 3) Chestnut Ridge, 4) Bethel Valley, 5) probable A.E.C. construction site, 6) Haw Ridge, 7) Melton Valley and White Oak Lake, south toward the Clinch River-Melton Hill Reservoir are mixed fields - deciduous woods - pine plantings, 8) Hood Road, 9) Beaver Ridge.

Lovell Quadrangle

1) Pine Ridge, 2) Chestnut Ridge, 3) Raccoon Valley, 4) Haw Ridge, 5) agricultural fields, 6) Copper Ridge, 7) Beaver Ridge, 8) Blackoak Ridge, 9) Beaver Valley, 10) Hardin Valley.

Bearden Quadrangle

1) Beaver Valley, 2) Beaver Ridge, 3) Hinds Valley, 4) Blackoak Ridge, 5) agricultural and forested ridges and valleys, 6) suburban strip development.

Knoxville Quadrangle

1) agricultural and forest area, 2) urban and suburban Knoxville, 3) Sharp Ridge, 4) Quarry, 5) Chapman Ridge, 6) Brown Mountain, 7) Tennessee River-Fort Loudon Reservoir.

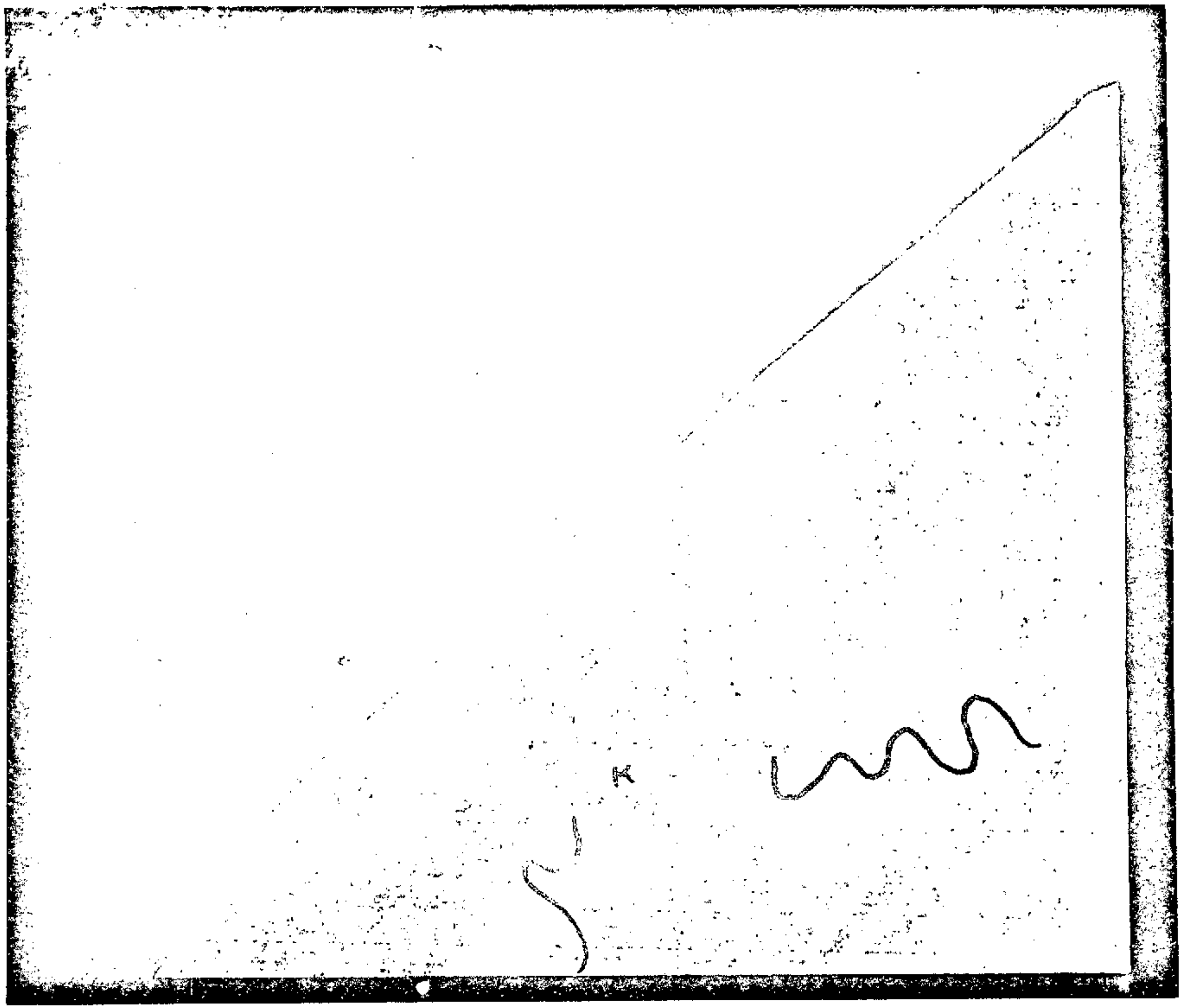

Figure 3. Area near Knoxville, Tennessee (K). Major streams and traffic arteries are visible. ERTS 1084-15431, band 4.

Some features visible on band 6 of Fig. 2 are more visible on band 4, Figure 3. The Tennessee River-Fort Loudon Reservoir and French Broad Rivers are difficult to follow (ink line), the forest vs. agricultural-urban-suburban pattern again appears, and roads and new construction sites in, around, and radiating from urban Knoxville(K) are quite evident.

The area to the northeast of Knoxville appears in Figure 4:

Graveston Quadrangle

1) Copper Ridge, 2) Comb Ridge, 3) Buffalo Ridge, 4) Miller Knobs, 5) Texas Valley.

John Sevier Quadrangle

1) House Mountain, 2) McAnnally-Baker-Meek-Rodgers-Legg Ridge, 3) Blackoak Ridge, 4) Beaver Ridge, 5) Hinds Valley, 6) unnamed ridges, 7) John Sevier freight yards, 8) John Pratt Hill, 9) newly cultivated fields, 10) Knoxville dashed line.

Mascot Quadrangle

1) McAnnally Ridge, 2) Holston River, 3) zinc tailings area, 4) agriculture-forest area without pronounced topography, 5) agricultural lands, 6) Bays Mountain.

Shooks Gap Quadrangle

1) urban-suburban Knoxville, 2) forest and agriculture, 3) Holston River, 4) French Broad River, 5) Pickel Island, 6) sinkhole lake, 7) Brown Mountain, 8) Betsy Mountain - Bowman Mountain - Red Ridge, 9) Bays Mountain, 10) Chapman Highway (U.S. 441), 11) heavy-use agriculture area, Dewey-Dunmore-Decatur soils.

Boyds Creek Quadrangle

1) forest-agriculture area, 2) Bays Mountain, 3) heavy agriculture,

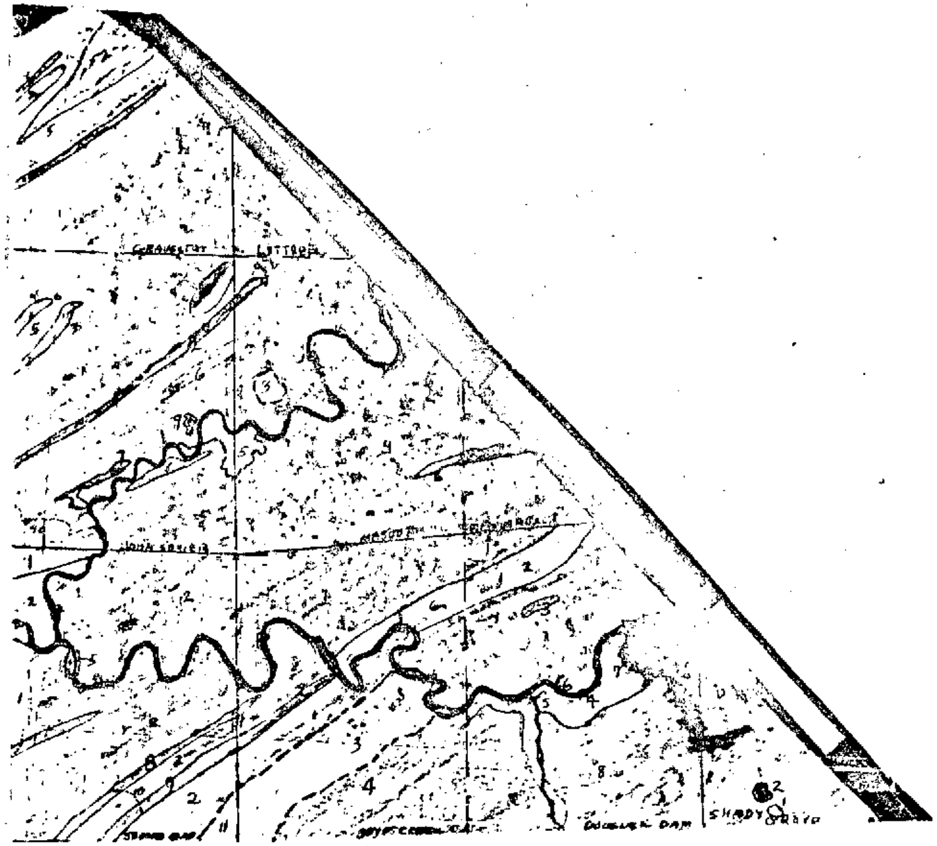

Figure 4. Quadrangles northeast of Knoxville, Tennessee. Derived from ERTS 1084-15431, band 7.

Dewey-Dunmore-Decatur soils, 4) shale ("slate") knobs, 5) French Broad River, light areas along river are high agricultural use terrace lands, 6) Dumplin Valley.

Douglas Dam Quadrangle

1) Forest-agriculture area, 2) Dumplin Valley, 3) Hester Knob, 4) terraces along 5) Little Pigeon River and 6) French Broad River, 7) Douglas Reservoir, 8) shale ("slate") knobs.

Shady Grove Quadrangle

1) clouds, 2) cloud shadows.

The area southwest of Knoxville (Figure 5) exhibits similarities:

Cave Creek Quadrangle

1) Great Valley area, 2) Dug Ridge, 3) Watts Bar (Tennessee River) Reservoir, 4) Wolf Creek Valley, 5) Cave Creek Valley, 6) Blackoak Ridge, Paint Rock Ridge.

Lenoir City Quadrangle

1) Great Valley area, 2) Watts Bar (Tennessee River) Reservoir, 3) Little Tennessee River, 4) Beaver Ridge, 5) Blackoak Ridge, 6) Hotchkiss Valley, 7) Chestnut Ridge.

Concord Quadrangle

1) Great Valley area, 2) Fort Loudon Lake (Tennessee River), 3) Blackoak Ridge, 4) parallel state road and Southern railroad track, 5) Little Tennessee River.

Louisville Quadrangle

1) Great Valley area, 2) Fort Loudon Lake, 3) Ish Creek embayment, 4) sinkhole lakes, 5) Jenkins Ridge, 6) Grey Ridge, 7) power line.

Figure 5. Quadrangles southwest of Knoxville, Tennessee.
Derived from 1084-15431, band 7.

Maryville Quadrangle

1) Little River embayment - Fort Loudon Lake, 2) Great Valley area, 3) airport, 4) Alcoa Aluminum factories, 5) Maryville-Alcoa, 6) Little River, 7) ridge area.

Philadelphia Quadrangle

1) Great Valley area, 2) Watts Bar (Tennessee River) Lake, 3) Stockton Valley, 4) Snow Ridge, 5) Matlock Ridge, 6) Watson Ridge, 7) U.S. 11 and Southern railway track.

Loudon Quadrangle

1) Great Valley area, 2) Watts Bar (Tennessee River) Lake, 3) Little Tennessee River, 4) U.S. 11, 5) Bat Creek Knobs (Holston Formation), 6) Loudon, 7) U.S. 11 and Southern railway track.

Meadow Quadrangle

1) Great Valley area, 2) Little Tennessee River, 3) Hickory Valley, 4) Red Knobs (Holston Formation), 5) Greenback.

Binfield Quadrangle

1) Great Valley area, 2) Grey Ridge, 3) Porter Ridge, 4) Sprading Ridge, 5) Peckerwood Knobs.

Blockhouse Quadrangle

1) Maryville urban and suburban area, 2) Great Valley area, 3) shale ("slate") knobs, 4) Little Mountain crest, 5) Great Smoky Mountains, 6) Chilhowee Mountain crest, 6) Lambeth Lake, 7) Lake-in-the-Sky, 8) Pea Ridge, 9) quarry.

Vonore Quadrangle

1) Great Valley area, 2) Little Tennessee River, 3) shale ("slate")

knobs, 4) mountains of Cherokee National Forest, 5) U.S. 411, 6) Tellico River, 7) Black Pond.

Tallahassee Quadrangle

1) Great Valley area, 2) shale ("slate") knobs, 3) Short Mountain, 4) Little Mountain, 5) TVA transmission line, 6) Chilhowee Mountain crest, 7) Shingle Mountain, 8) Little Tennessee River - Chilhowee Lake, 9) Cherokee National Forest.

Calderwood Quadrangle

1) Little Mountain, 2) Chilhowee Mountain crest, 3) Happy Valley, 4) Abrams Creek, 5) Chilhowee Lake - Little Tennessee River, 6) Great Smoky Mountains, 7) State Line Ridge, 8) Hannah Mountain, 9) Shunk Ridge, 10) Chilly Springs Knob, 11) TVA transmission line.

Southeast of Knoxville cloud cover increased but both Great Valley and Great Smoky Mountain landscape was visible (Figure 6).

Wildwood Quadrangle

1) Johnson Mountain, 2) Red Mountain, 3) Bays Mountain, 4) Great Valley area, 5) shale ("slate") knobs, 6) Great Smoky Mountains, 7) Chilhowee Mountain bluff, 8) Little River, 9) Dewey soils area.

Walden Creek Quadrangle

1) Dewey soils area, 2) shale ("slate") knobs, 3) Big Pine - Little Pine - Sugarloaf Mountains, 4) Great Smoky Mountains, 5) Chilhowee Mountain, 6) North Bluff of Chilhowee Mountain, 7) Walden Creek Valley, 8) Murray Ridge, 9) Laurel Creek Valley, 10) Laurel Branch Valley.

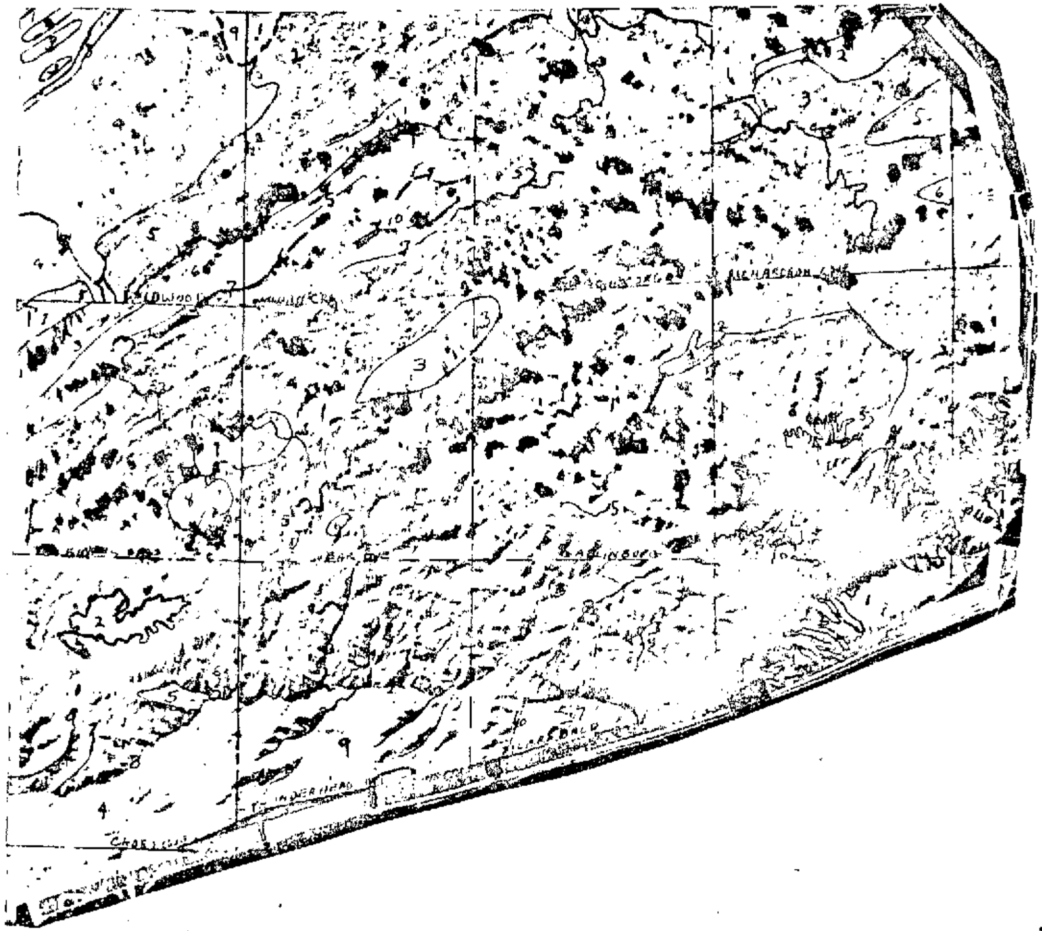

Figure 6. Quadrangles southeast of Knoxville, Tennessee. Derived from ERTS 1084-15431, band 7.

Pigeon Forge Quadrangle

1) Sevierville, 2) Little Pigeon River, 3) West Fork Little Pigeon River, 4) U.S. 441 in Gists Creek Valley, forest edge at Walden Creek Valley.

Richardson Cove Quadrangle

1) Dolomitic-limestone valley area, 2) shale ("slate") knobs, 3) Great Smoky Mountains, 4) Little Pigeon River, 5) Bearwallow and Short Mountains, 6) Webb Mountain.

Kinzel Springs Quadrangle

1) Great Valley area, 2) shale knobs, 3) Chilhowee Mountain, 4) Miller Cove, 5) Little River, 6) Laurel Lake, 7) Tuckaleechee Cove, 8) Dry Valley.

Wear Cove Quadrangle

1) Great Smoky Mountains, 2) Tuckaleechee Cove, 3) Wear Cove, 4) Little River, 5) Laurel Creek, 6) Camp Townsend area.

Gatlinburg Quadrangle

1) Great Smoky Mountains, 2) Gatlinburg, 3) Wear Cove, 4) Little Pigeon River Valley, 5) Little River.

Mount LeConte Quadrangle

1) Great Smoky Mountains, 2) Gatlinburg, 3) Dudley Creek, 4) Little Pigeon River, 5) spruce-fir vegetation enclosed by ink line.

Clingmans Dome Quadrangle

1) Great Smoky Mountains, 2) spruce-fir vegetation.

Silers Bald Quadrangle

1) Great Smoky Mountains, 2) spruce-fir vegetation, 3) Bend

Arm Ridge, (4) Miry Ridge, 5) State Line Ridge, 6) Proctor Ridge, 7) Firescald Ridge, 8) Fish Camp Prong.

Thunderhead Mountain Quadrangle

1) Great Smoky Mountains, cool (dark) northslope, 2) State Line Ridge, 3) Defeat Ridge, 4) Brier Ridge, 5) DeArmond Ridge, 6) Jenkins Trail Ridge, 7) Chestnut Ridge, 8) Locust Ridge, 9) warm (low density) south slope.

Cades Cove Quadrangle

1) Great Smoky Mountains, cool (high density) north slope, 2) Cades Cove, 3) State Line Ridge, 4) warm (low density) south slope, 5) south slope Pole Knob, 6) Russell Field, 7) Gregory Ridge, 8) Pine Ridge - High Point.

A Remote Sensing Legend System

A model has been sought to categorize the land features visible on ERTS-1 imagery of the East Tennessee-Western North Carolina study area. The comprehensive remote sensing legend system of Poulton (1972) has been modified to fit the unique character of the study area, but includes categories particularly relevant to ERTS-1 imagery at scales and considering methods used here.

The symbolic legend classes have been eliminated in the study area, much is known on the ground, and it is scarcely necessary to guess cartographic classes from the imagery. The descriptive and interpretive legends are combined. In general the legend reads general to specific, interpretive to descriptive, left to right. As in other such systems the numerator deals with above ground features and places them in genetic units; the denominator classes physical environment and places its components into genetic classes:

$$\frac{A - B - C}{I - II - III - IV}$$

A. Gross resource of the following types:

1. Urban, suburban, other lands.
2. Rural lands with fields, woods, farm buildings and small forest areas.
3. Forests with small cultivated, old field or other (as road) areas.

B. Secondary level; types of A:

1. Urban, suburban, other:
    a. Urban areas.
    b. Suburbs.
    c. Strip developments

d. Auxiliary city services, etc., including:

1) air fields.

2) purification and sewage plants.

3) dumps and landfills.

4) roads.

5) pipe, electric lines.

6) barren: quarries, barrow pits, development cuts, reservoir edges.

2. Rural lands:

a. Croplands.

1) Separately by crop when possible.

b. Pastureland.

1) Separately by degree of weed grass and brush invasion where possible.

c. Farms - roads, lanes, buildings, inclusions of 1d.

3. Forest land with inclusions of 2 and 1c, d:

a. Conifer forest land.

b. Hardwood forest land.

c. Mixed forest land.

d. Other types.

C. Tertiary level; types of B:

1. Urban, etc., see above.

2. Rural lands, see above.

3. Forest land:

a. Conifer forest land:

1) Plantations:

a) Loblolly pine.

b) Shortleaf pine.

c) Virginia pine.

d) White pine.

2) Natural-managed lands:

a) Cedar.

b) Pines:

i. Virginia pine.

ii. Shortleaf pine.

iii. Pitch pine.

iv. Table Mountain pine.

v. White pine

c) Hemlock.

d) Spruce-fir.

b. Hardwood forest land:

1) Swamp forest:

a) Riverine forests.

b) Upland swamp forests.

2) Mixed mesophytic forests.

3) Oak Forests:

a) Northern Red oak.

b) White oak.

c) Chestnut oak.

d) Post oak.

c. Mixed conifer-deciduous forests.

1) Cedar-Hardwood.

2) Cedar-Pine-Hardwood.

3) Pine-Hardwood.

4) Hemlock-Hardwood.

5) Spruce-Hardwood.

d. Other natural-managed areas:

1) Cedar glades.

2) Heath slicks.

3) Old fields.

4) Grass balds.

5) Marsh.

I. Macrorelief type:

1. Unaka Mountains:

a) Mountain-valley systems.

b) Low hill or mountain-structural basin systems.

2. Valley and Ridge:

a) High prominent ridges.

b) Ridge and valley lands.

c) Valley with small ridge lands.

3. Cumberland Plateau and Mountains:

a) Mountains-valleys.

b) Level to rolling surfaces.

c) Dissected intrusions.

d) Escarpments.

II. Landforms within I above:

1. Flat-gentle slopes: plateau surface and valleys.

2. Slopes - moderate to steep - upper 3/4 positions.

3. Valley bottom and lower slopes.

4. Crest, bluff and cliffs.

5. Water.

III. Surface geology within I above:

1. Unaka Mountains.

a) Basement Complex: chiefly gneiss, schist, granite.

b) Snowbird Group: chiefly quartzite, sandstones, siltstones.

c) Ocoee Series: unclassified formations: chiefly sandstones.

d) Walden Creek Group: chiefly shale, siltstones, conglomerate, sandstone, etc.

e) Great Smoky Group: chiefly sandstones.

f) Chilhowee Group: chiefly shales, quartzites.

g) Blockfields and fans.

2) Valley and Ridge Area:

a) High Ridges of Silurian Rockwood Formation, Clinch sandstone (sandstones, siltstones, shales), and Mississippian Newman Limestone and Pennington Formations (sandstone, siltstone, shale).

b) High Ridges of the Rome Formation (sandstone, shale).

c) Knobs and ridges of Chapman Ridge Sandstone.

d) Ridges and rolling lands of Knox Group dolomites and Maryville, Maynardville, Rutledge dolomites and limestones.

e) Knobs of the Athens, Ottosee, Sevier shales.

f) Bluffs and outcrops of Chickamauga, Lenior limestones.

g) Shale valleys of Nolichucky and Pumpkin Valley shales.

h) High terraces from limestone.

i) Low terrace, floodplains, chiefly from limestone.

j) Low terraces, flood plains, from limestones, sandstones or shales.

3) Cumberland Mountains and Plateau area:

a) Mountains: six formations of alternating Pennsylvanian beds of conglomerate, sandstone, siltstone, shale and coal.

b) Plateau surface: three groups composed of 14 named units of Pennsylvanian conglomerate, sandstone, siltstone, shale and coal.

c) Dissections and escarpment area: Pennsylvanian Gizzard Group with three named units of shale, siltstone, sandstone, conglomerate and coal; Mississippian Pennington and Hartselle Formations of shale, limestone, siltstone, dolomite and sandstone, and Bangor, Monteagle, St. Louis and Warsaw limestones.

d) Alluvial terraces of major stream valleys and in the Sequatchie Valley.

IV. Soil series and types:

1. Unaka Mountains: soils are poorly known at the series level.
2. Valley and Ridge: in the 10 major landscape types about 40 soil series cover most of the area.
3. Cumberland Mountains and Plateau: soils are not well known at the series level; the 17 series named in Cumberland County (1950) have 40 phases.

The above represents a potentially useful scheme. Due to the lack of funds, no type mapping of areas has been accomplished.

Forest Cover - Morgan County

Recently available is a forest cover map of Morgan County, Tennessee, prepared by Tennessee Valley Authority personnel. It depicts deciduous, mixed and coniferous types and non-forest areas at 1:120,000. Forty acre blocks were classified by type using an overlay grid and the map colors reflect the angular grid system. No correspondence is seen between this and ERTS-A imagery visually. The difference in actual resolution of 40 acre minimal units to 1-2 acre minimal units doubtless accounts for this lack of correspondence.

Wilson Mountain - Morgan County

Comparison between pine and hardwood vegetation types on Wilson Mountain based upon 14 April, 1973, imagery No. 15494-6 is as follows:

Density	Number Counted	Pine	Pine Hardwood	Hardwood Pine	Other Hardwoods
			Percent		
118-136	18	<0.1	0	<0.1	3.6
137-156	432	1.0	4.7	7.6	82.7

As indicated in the data above and in Figure 7, band 6 did not distinguish vegetation types to a great extent.

Forest Versus Non-Forest Areas, Mascot Quadrangle

Forest edge as represented by green overlay on the Mascot T.V.A. quadrangle (1:24,000) and checked on the NASA RB-57 imagery (1:120,000) was compared with symbol distribution on the printout by conversion of the forest edge boundary to 1:32,000 using the Map-o-graph:

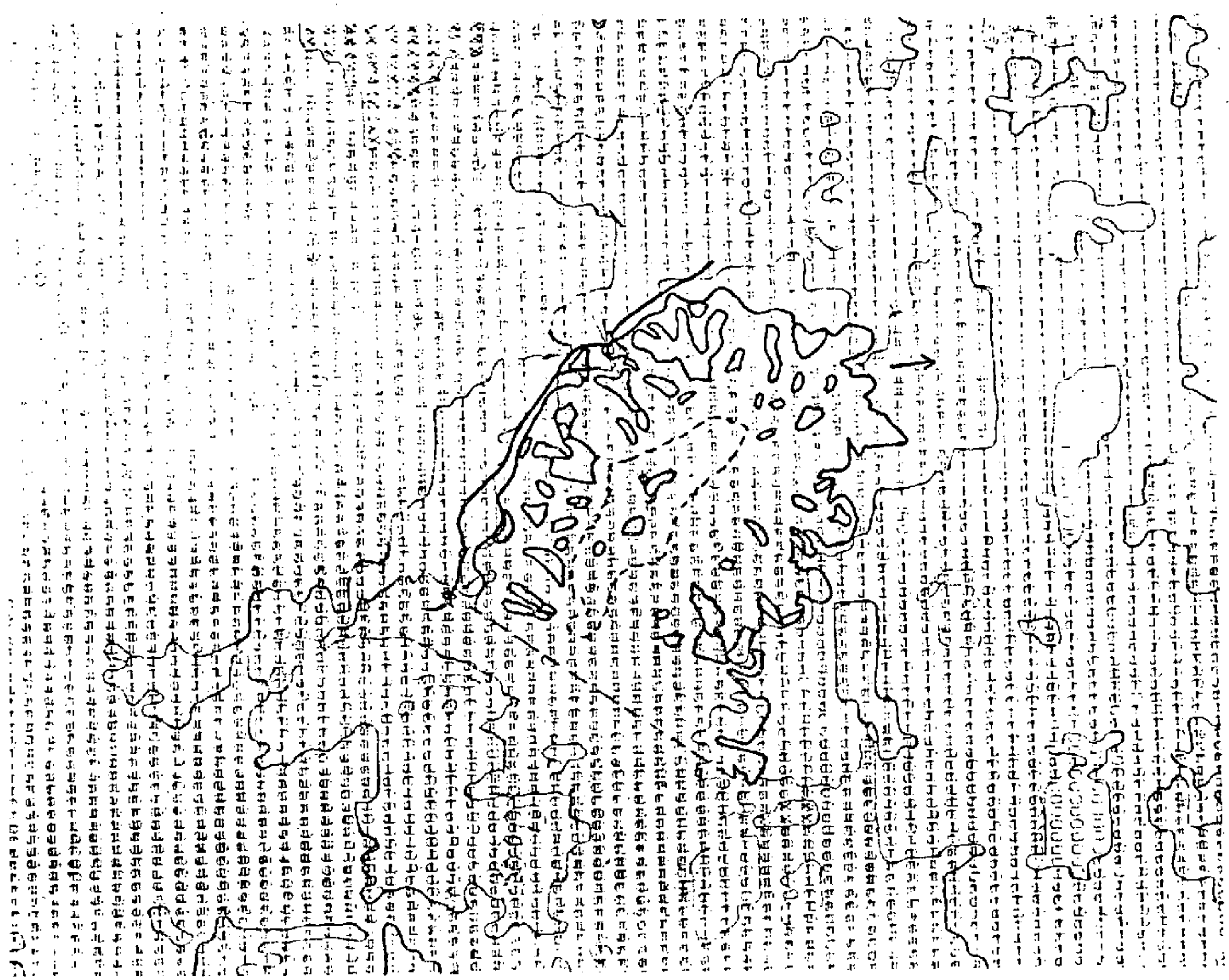

Figure 7. Vegetation map of Wilson Mountain. This is photographed over microdensitometer scan of ERTS imagery (15494-6).

Symbol	BAND 4 Forest	4 Non	5 Forest	5 Non	6 Forest	6 Non
Total	1030	635	987	816	1028	1553
x					0.3	0.3
O	0.9	2.4	0.0	0.1	70.6	90.3
Θ	68.4	65.0	11.7	21.2	29.1	9.1
⊜	29.9	32.0	73.2	64.7	0.0	0.3
⊗	0.7	0.6	14.8	13.6		
⊛	<0.1	0.0	0.3	0.3		

Thus within each band comparisons can be made. On band 4, forest edge does not appear. Probable real differences in frequency of symbols Θ and ⊜ occur in band 5 but not at a level to separate this land use type. On band 6, symbols O and Θ differences are probably real but do not statistically separate forest from non-forest adequately. Rarely did symbol boundaries follow forest edge boundaries.

Principal Forest Types Map Comparison

Gross forest types as represented on the Tennessee Valley Authority map "Principal Forest Types in the Tennessee Valley" at 1:629,000 were compared with a microdensitometer printout at 1:32,000 of a strip extending through Knox County well into Blount County from the 15 October, 1972, imagery (1084-15431). The Forest Types map boundaries were traced onto an overlay at 1:32,000 and comparisons were made directly (Table 1). It should be noted that at this period of autumn coloration the color bands 4 and 5 are not interpretable even though vegetation colors green

Table I. Comparison of T.V.A. Principal Forest Types map boundaries with 15 October, 1972, ERTS-A imagery printouts.

	Numbers[a] of boundary instances	BANDS 4	5	6	7
		Percentage Partial Agreement			
Upland hardwood on Yellow pine-hardwood	8	0	0	13	0
Upland hardwood on Oak-chestnut	3	0	0	33	0
Upland hardwood on Cedar-hardwood	2	0	0	0	50
Yellow pine-hardwood on Oak-chestnut	5	0	0	0	0
Yellow pine-hardwood on Yellow pine	1	0	0	0	0
Yellow pine-hardwood on Cedar-hardwood	6	0	0	17	0
Oak-chestnut on Cedar-hardwood	1	0	0	0	100

[a]Representing separate "islands" within another type matrix
Each instance represented an average of 1-5 miles of boundaries

through red are present on the ground. Bands 6 and 7 extreme red and infra red are suggestive. On band 6, partial agreement was seen along boundaries between three different vegetation type pairs; typically this agreement was for a portion of an area and for similar boundaries. Two instances of contact between cedar-hardwoods and other types are seen on band 7. These proved to be edges of ridges where valley cedar was replaced on the ridge slope with "upland hardwood" or "oak-chestnut".

Oak Ridge National Laboratory Land Use Comparison

A comparison was made between pine and hardwood vegetation on the Oak Ridge National Laboratory lands using 19 February, 1973, imagery No. 15493-6.

Density	Number Counted	Cedar-Hardwood and Yellow Pine Hardwood	Yellow Pine	Cedar and Cedar-Pine
118-136	3	0	0	0.1
137-156	217	20.9	12.8	3.1
157-176	353	29.7	20.0	11.2
177-195	24	0.1	1.6	2.1

As seen from the ratios above, band six and in Figure 8, vegetation types are not well distinguished.

Little River Multistage Vegetation Classification

Multistage examination of vegetation gradients within a sample area approximately 1.5 km^2 located in the Kinzel Springs, Tenn. 7.5 Minute U.S.G.S. Quadrangle was completed in order to determine levels of detection of vegetation boundaries. Four sources of information were employed in the

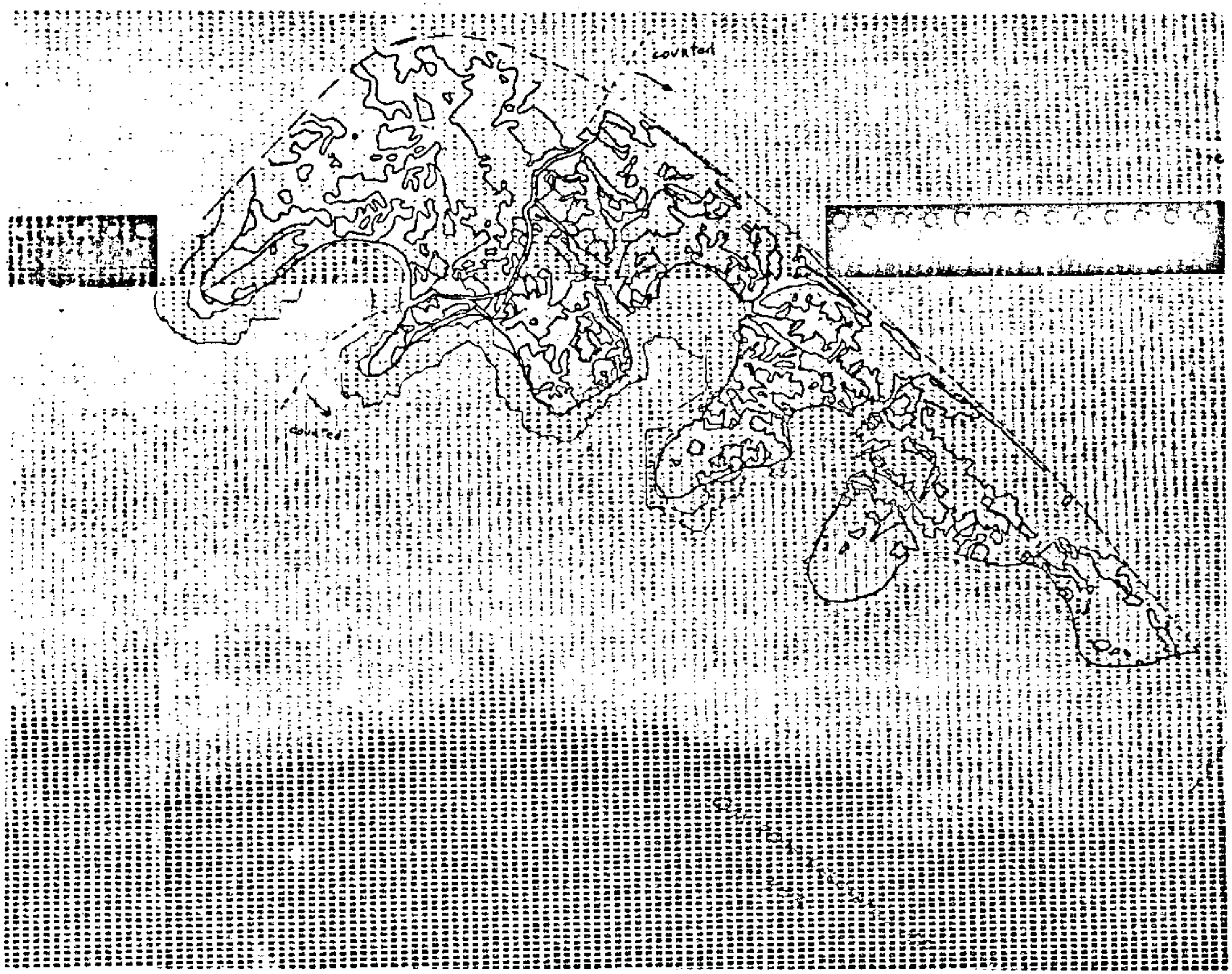

Figure 8. Overlay of cedar, pine and these with hardwoods. Area is Oak Ridge National Laboratory on a microdensitometer printout of imagery from ERTS-1 (15493-6).

investigation: The vegetation map at the scale of 1:24,000 prepared by Miller in 1941, NASA Mission 193, 18 April, 1973, false color infrared imagery roll 27 frame 270 at a scale of 1:60,000, NASA Mission 193 false color infrared imagery roll 26 frame 130 at a scale of 1:120,000, and NASA ERTS-1 image 1084-15431 recorded from MSS band 5 dated 15 October, 1972, at the approximate scale of 1:1,000,000. The particular site of study was chosen because it was located near two distinctive bends in Little River that could be located on all information sources and because the Miller map and ground observation indicated that sharp interfaces between conifer and hardwood vegetation types were present. Pines predominate among the conifers, and oak-hickory second growth forests are the most representative hardwood types.

The Model 55 Map-O-Graph was used for multistage enlarging of all images to a 1:24,000 scale in order that all mapping could be done on the scale of the U.S.G.S. Quadrangle. Communities were mapped as located on the imagery and visual comparisons made among the four sources. The 1:1,000,000 scale ERTS imagery generated the least detailed information due to the extremely small scale and the resolution characteristics of the multi-spectral scanner. Only two vegetation types were detected for classification (Coniferous and Non-Coniferous), and the boundaries for these were not distinct (Figure 9). However, the position and shape of these coniferous stands as sensed by the ERTS MSS system does indicate that detection of this forest type is scarcely feasible on a meaningful scale by this spacecraft using the MSS scanner device. The RB-57 images of 1:60,000 (Figure 10) and 1:120,000 (Figure 11) produced almost parallel data with the expected exception that the 1:60,000 imagery generated maps of greater detail and complexity. With

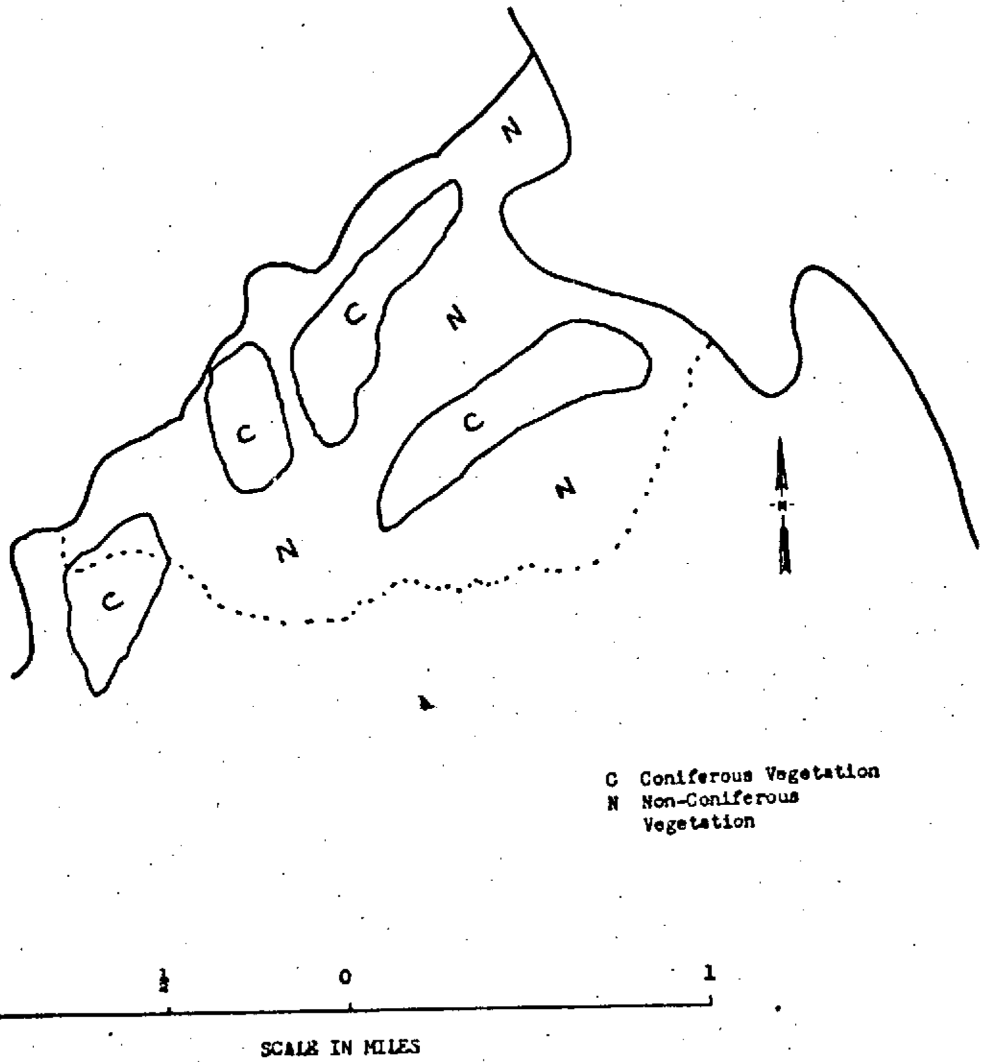

Figure 9. Vegetation types classed using ERTS-1 imagery (1084-15431), band 5.

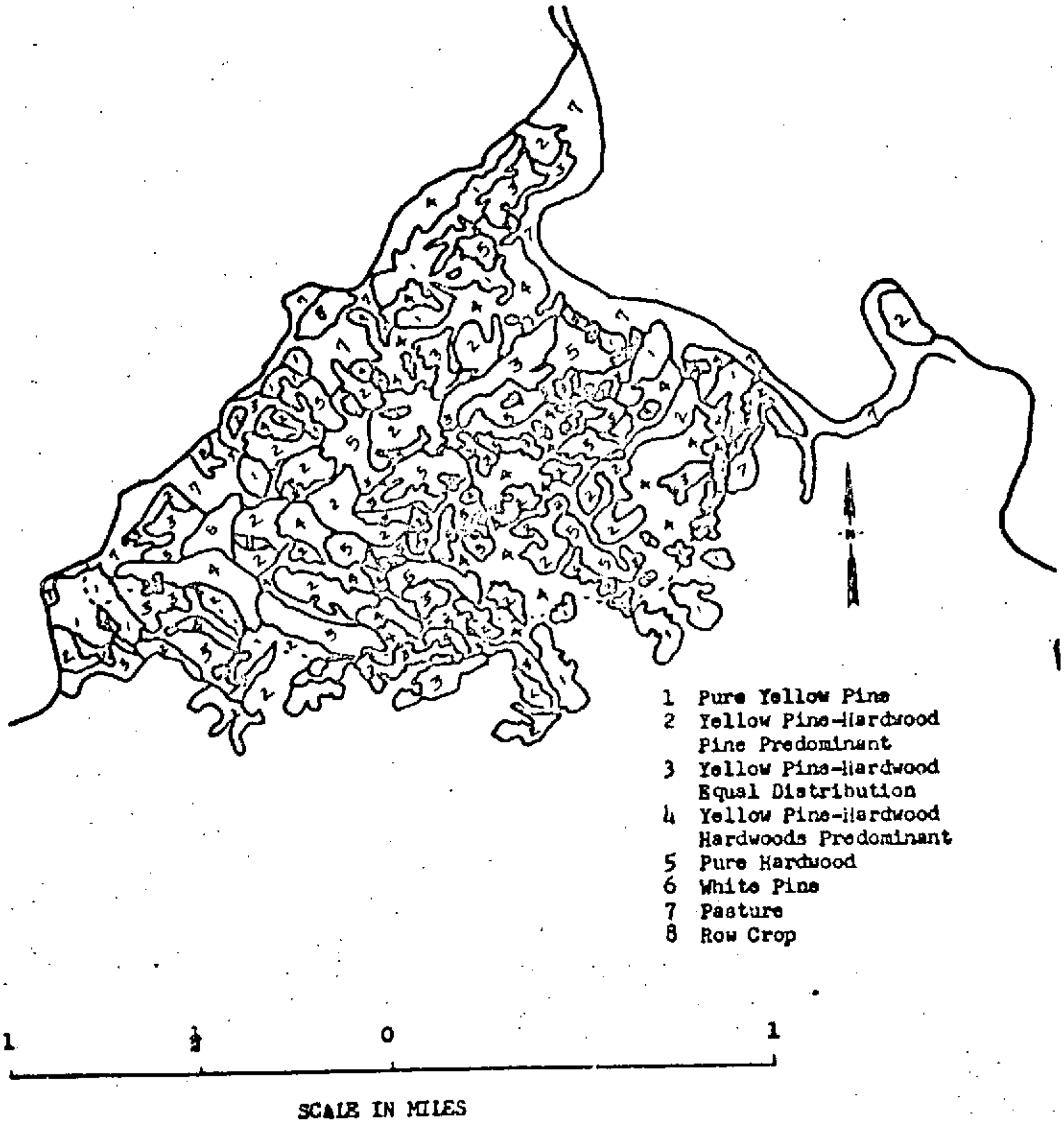

Figure 10. Vegetation types classed using IR false color 1:60,000 scale imagery.

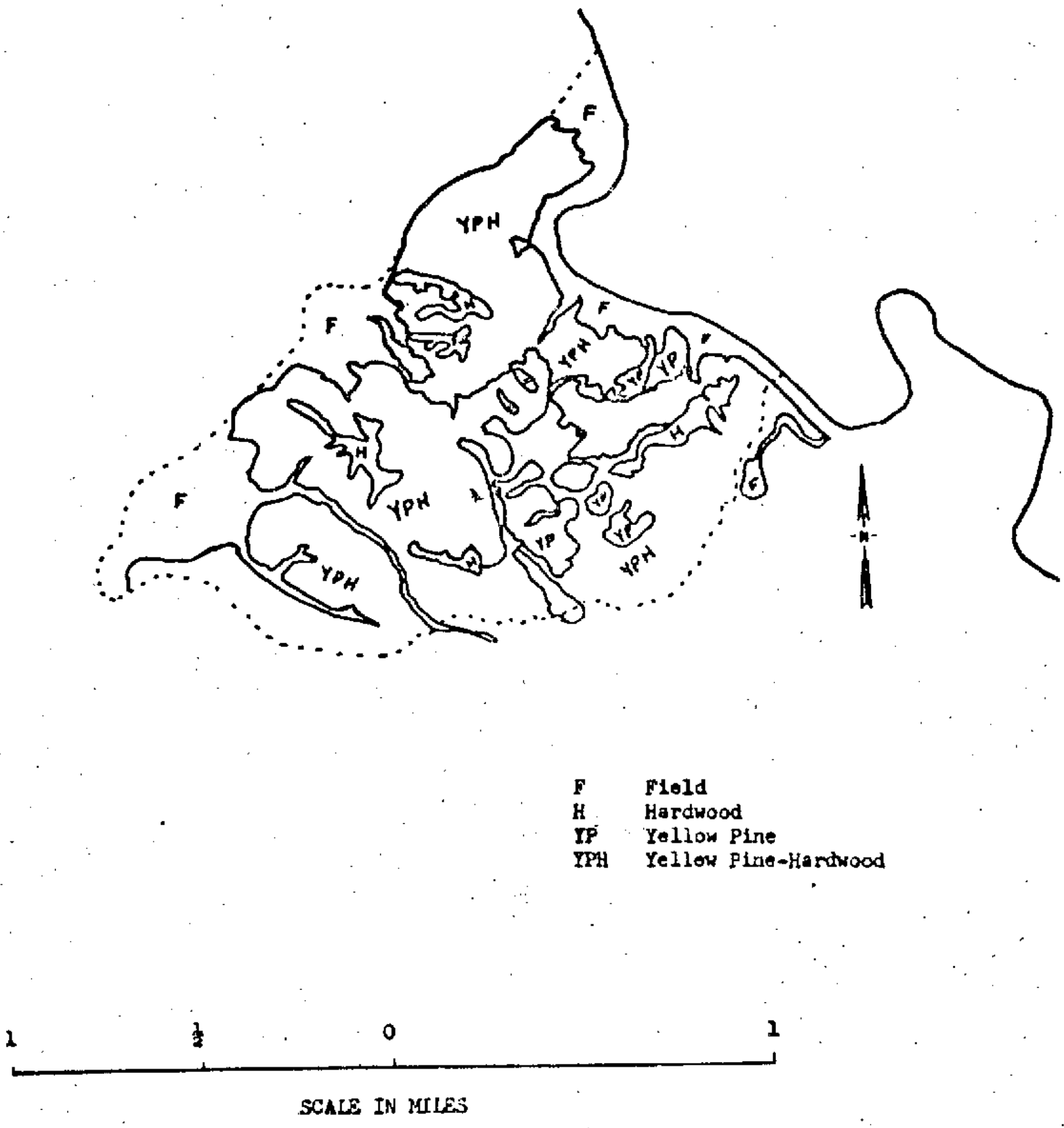

Figure 11. Vegetation types classed using IR false color imagery at 1:120,000.

magnification, individual trees were discernible on the 1:60,000 imagery. From the two RB-57 images, vegetation type maps that represent a close approximation of ground truth were drawn. The Miller map (Figure 12) was included only as a control factor for vegetation type identification.

Chilhowee Mountain Studies

Comparison of the vegetation map of Thomas (1966) (Figure 13) and Schnabel (manuscript map) (Figure 14) with a printout from imagery (1084-15431-6) of Chilhowee Mountain indicates the lack of correspondence due in part to cloud cover and in part to the difference in scales of the maps versus imagery.

However, an additional study was made which it is hoped can eventually be developed into an aid to image interpretation wherein site characteristics correlated to vegetation characters supplement image observations. A study which attempts to use correlations between physical features of the environment at transect points on and adjacent to Chilhowee Mountain, Sevier County, Tennessee, with mesophytism of the vegetation has been completed. Variables used were:

Elevation - feet above msl

Aspect - [4 cos (418° - degrees from north)] + 5

Micro aspect - 40 acre site

Local aspect - 400 acre site

Slope angle - percent

Across slope shape (40 acre site) - coded 1 (very concave) to 5 (flat) to 9 (very convex).

Microslope position (40 acre site) - coded 1 (crest) to 9 (footslope).

Local slope position (400 acre site) - coded as above.

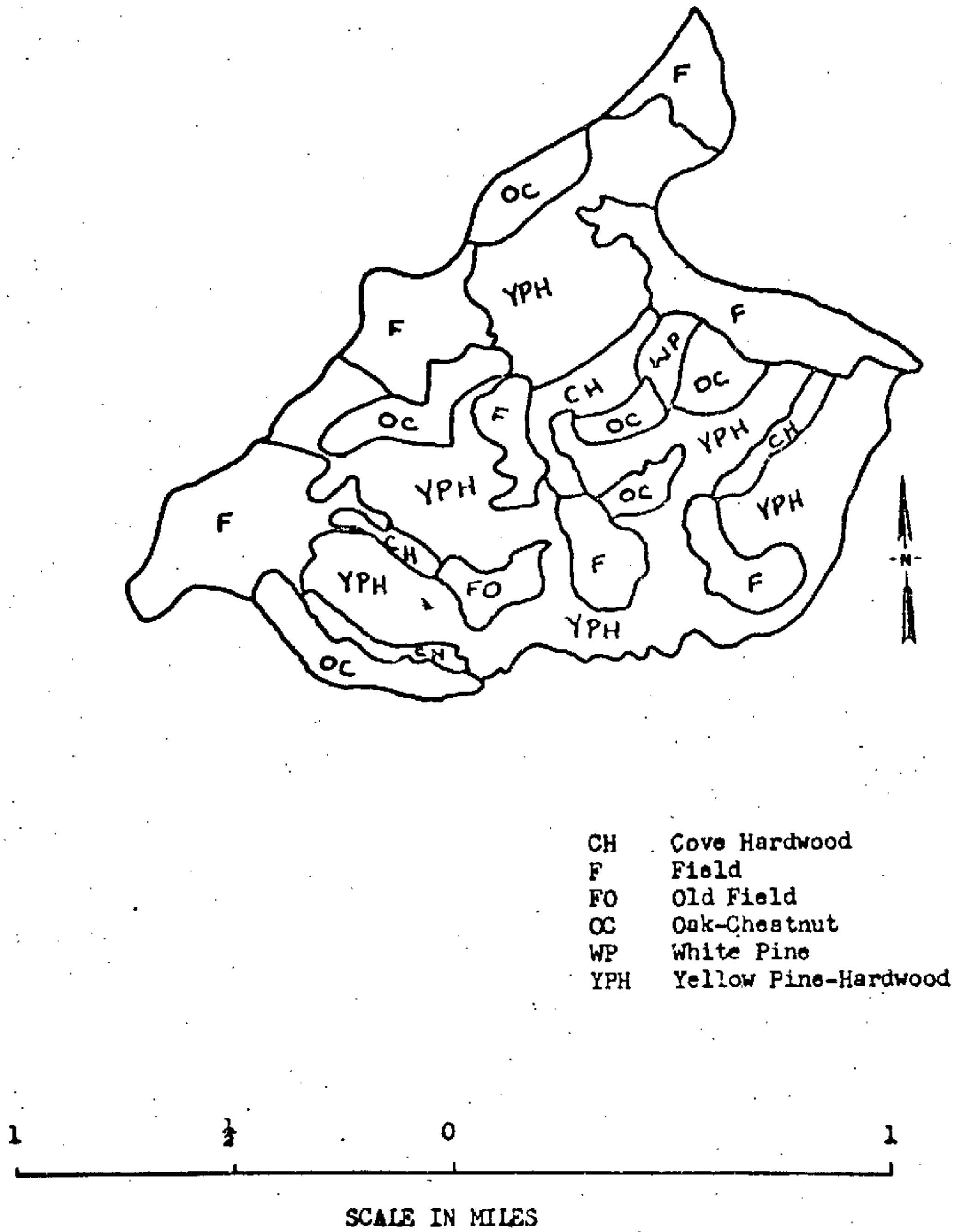

Figure 12. Vegetation types as classed on the 1941 Miller map of the Great Smoky Mountains National Park.

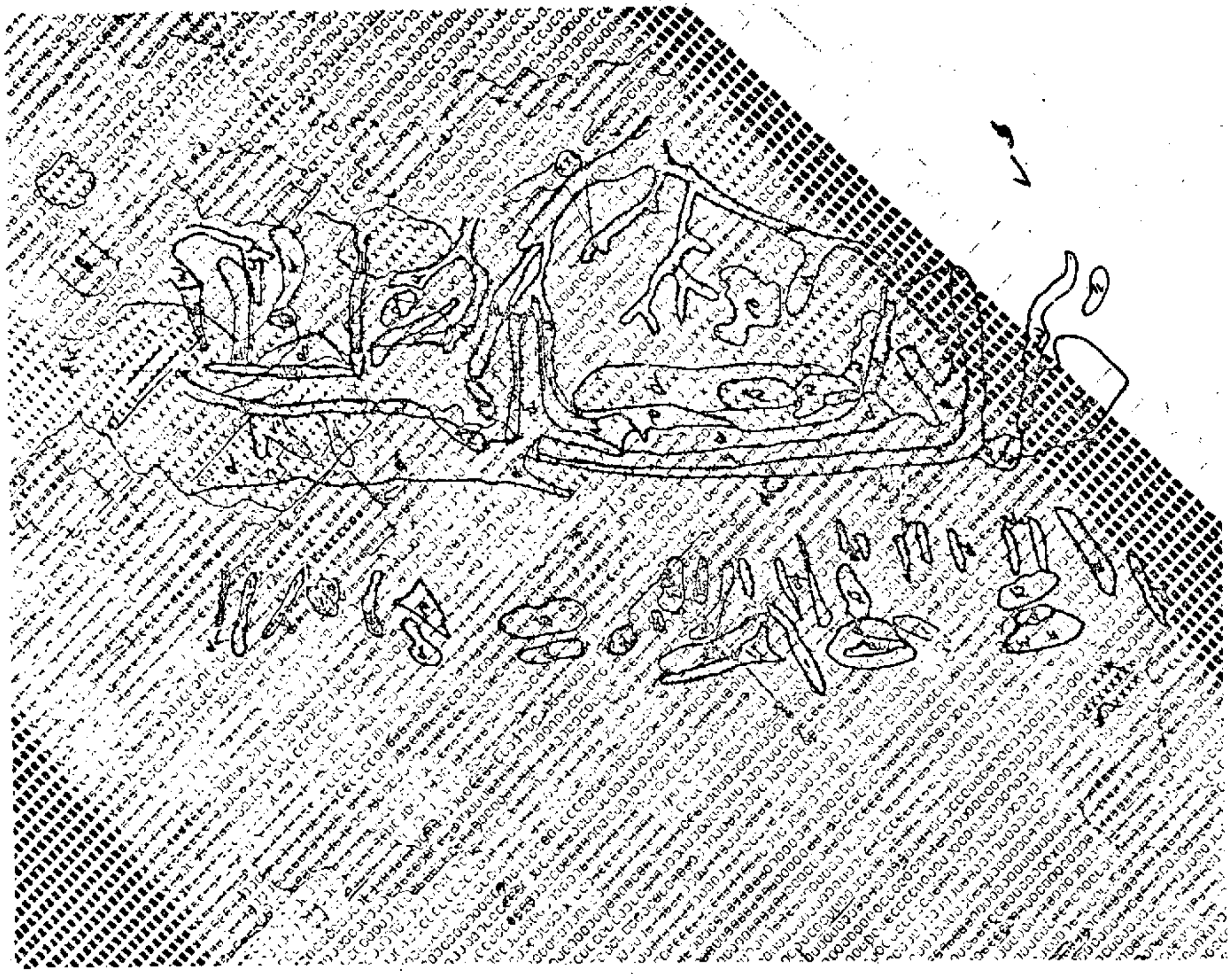

Figure 13. Thomas vegetation map of Chilhowee Mountain. It overlays ERTS microdensitometer printout.

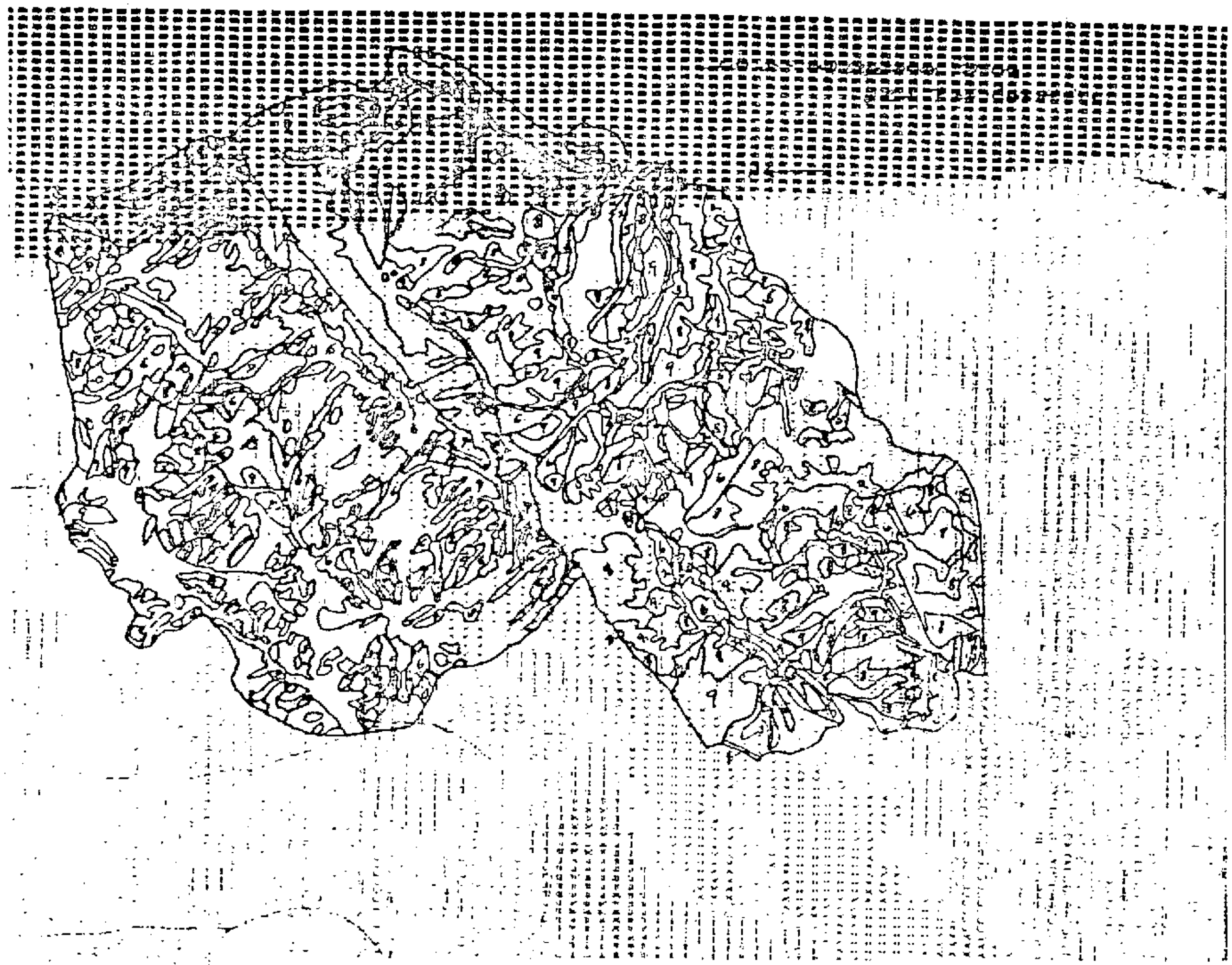

Figure 14. Schnabel vegetation map of Chilhowee Mountain.

Soil type - 1 (stony, sandy, steep, upper slope soils) to 9 (bottom-land, silty soils).

Vegetation scale - tulip/pine % density 10 to 1 to 0.1.

These data were used as collected or transformed as x^2, x^3, x^5, e^x, x^x, $\log_{10}x$, $\log_{10}y$, sq. root y.

The data were obtained from U.S.G.S. 7.5 minute quadrangle topographic maps, soil maps (Hubbard, et al., 1956) and the vegetation-land use map prepared from NASA mission 193, 18 April, 1972, ecktachrome color and I.R. false color 1:60,000, and 1:120,000 scale imagery by R. Schnabel. A transect drawn across the study area maps provided the location of 95 regularly spaced data points.

By their nature certain listed variables are significantly correlated, e.g., elevation on log elevation, local on micro aspect, elevation on slope position (Table 2). Sine transformations were of little value.

Of particular interest however is the relation of site and soil characteristics to vegetation character. Vegetation mesophytism is negative on elevation ($r = -0.409$, -0.418), positive on soil character (+0.390) and on slope position (+0.375 to +0.464). The best variable was micro slope position cubed with an $r = +0.464$. Apparently the north slope relationships are those best reflecting those causes (Table 3) as north slope correlations are about a half again to three times higher than those on the south slope. While the general relationships of soil and microclimatic conditions to slope position and these to vegetation mesophytism are known, just why these should be so much better expressed on the north aspect is conjectural.

In interpreting small scale imagery where mesophytes as hemlock and indifferents as white pine and cedar, and xerophytes as Appalachian pines

TABLE 2. Correlation Matrix among Vegetation and Site Variables.

Code	Name/Descr.	ELEV	LOGE	SINE	FAC	GO	GO2	HI	LOGH	SINH	J	K	L	MA	K3	L3	VY
ELEV	Elevation (feet)	--	.994	.029	-.015	.094	.078	.489	.472	-.055	.050	-.589	-.937	-.265	-.541	-.900	-.409
LOGE	Log ELEV		--	.047	-.006	.127	.103	.497	.485	-.037	.056	-.585	-.923	-.300	-.550	-.914	-.418
SINE	Sine ELEV			--	-.106	-.124	-.171	-.077	-.128	-.029	-.068	-.056	-.072	.027	-.065	-.077	-.085
FAC	Micro Aspect				--	.585	.570	.237	.233	-.021	-.040	-.166	.033	-.040	-.225	.032	.087
GO	Local Aspect					--	.975	.291	.309	-.005	.009	-.303	-.051	-.199	-.288	-.100	.077
GO2	GO^2						--	.277	.293	-.058	.004	-.307	-.027	-.168	-.286	-.068	.112
HI	Slope Angle (%)							--	.924	.043	.072	-.557	-.504	-.173	-.538	-.485	-.252
LOGH	Log HI								--	.115	.021	-.514	-.478	-.133	-.521	-.488	-.265
SINH	Sine HI									--	.067	.038	.068	-.130	-.066	-.008	-.238
J	Across-slope Position										--	.105	-.057	-.037	.140	-.056	.039
K	Micro-slope Position											--	.649	.192	.935	.600	.375
L	Local-slope Position												--	.237	.583	.942	.413
MA	Soil Type													--	.243	.330	.390
K3	K^3														--	.593	.464
L3	L^3															--	.453
VY	Vegetation (descr)																--

TABLE 3. Correlations of Site Variables to Vegetation.

x variables		Complete Transect n=96			Northwest Slope n=41			Southeast Slope n=55		
Code	Name	$r_{x \cdot vy}$	$r_{x \cdot \log v}$	$r_{x \cdot rv}$	$r_{x \cdot vy}$	$r_{x \cdot \log v}$	$r_{x \cdot rv}$	$r_{x \cdot vy}$	$r_{x \cdot \log v}$	$r_{x \cdot rv}$
ELEV	Elevation(ft)	-.409	-.351	-.385	-.392	-.316	-.357	-.400	-.422	-.414
FAC	Micro-aspect	.087	.140	.117	-.099	-.127	-.113	.457	.514	.492
GO	Local-aspect	.077	.201	.142	-.210	-.107	-.161	.536	.575	.562
HI	Slope(%)	-.252	-.205	-.228	-.317	-.343	-.330	.013	.059	.038
K	Micro-slope position	.375	.322	.351	.522	.532	.531	.116	.049	.080
L	Local-slope position	.413	.387	.404	.433	.391	.415	.371	.396	.385
M	Soil type	.363	.244	.305	.378	.295	.338	.197	.124	.157
E2	$ELEV^2$	-.396	-.347	-.377	-.376	-.307	-.345	-.399	-.423	-.413
F2	FAC^2	.073	.136	.108	-.116	-.132	-.125	.436	.502	.475
G2	GO^2	.112	.226	.173	-.205	-.105	-.158	.549	.583	.573
H2	HI^2	-.222	-.190	-.205	-.314	-.354	-.333	.018	.062	.042
K2	K^2	.427	.358	.395	.573	.570	.577	.150	.066	.104
K3	K^3	.464	.387	.429	.605	.594	.606	.181	.086	.130
L2	L^2	.438	.393	.420	.472	.411	.448	.358	.380	.371
L3	L^3	.453	.394	.427	.511	.428	.474	.330	.351	.342
M2	M^2	.375	.265	.322	.367	.293	.332	.268	.202	.243
ES	$\frac{ELEV-300}{700}$	-.409	-.351	-.385	-.391	-.316	-.357	-.400	-.423	-.414
ES2	ES^2	.392	-.345	-.374	-.371	-.305	-.342	-.398	-.423	-.413
LOG E	Log_{10} ELEV	-.416	-.351	-.389	-.400	-.318	-.361	-.398	-.419	-.411
LOG F	FAC	.094	.130	.116	-.074	-.116	-.094	.444	.490	.473
LOG G	" GO	.015	.142	.081	-.228	.124	-.177	.485	.527	.512
LOG H	" HI	-.285	-.223	-.254	-.315	-.315	-.315	.003	.045	.024
LOG M	" M	.298	.180	.239	.360	.276	.319	.060	.003	.028
LOG S	" ES	-.419	-.350	-.389	-.400	-.317	-.361	-.397	-.417	-.410
VY	Vegetation(scale)	--	.950	.988	--	.952	.989	--	.964	.990
LOG V	Log_{10} VY	.950	--	.986	--	--	.986	--	--	.992
RV	$\sqrt{VY}$	.988	.986	--	--	--	--	--	--	--

are not easily distinguished, the use of this information separately by factor or in groups of factors (Table 4) will increase precision.

It is hoped that funds will be found to develop this aid to interpretation of small scale imagery.

Mount Mitchell Fir Mortality Study

A comparison was made among forest types with different degrees of fir mortality at Mount Mitchell, North Carolina, based upon 3 September, 1973, imagery no. 15364, band 6.

Density	Number Counted	No Mortality	1-75% Mortality	76-100% Mortality
		- - - - - - -	percent - - - - -	- - - - - -
98-117	1101	29.1	32.3	1.4
118-136	433	12.1	12.6	0.0
137-156	23	0.7	0.6	0.0
157-176	196	4.3	6.9	0.0

As suggested from the data above and Figure 15, the mortality classes are not well separated by density.

Comparison of Oak and Hemlock Forest Boundaries: ERTS-1 Derived Printout and the 1:24,000 Map

Hemlock forest and oak forest boundaries were transferred from the base map at 1:24,000 to an overlay at 1:31,500 and compared directly to the ERTS-1 (1084-15431-6) derived printout at the same scale (Table 5). The overlapping of percent density distribution between vegetation types in the bands in Table 5 suggests that those types are not well differentiated nor can they be well delineated on ERTS-1 imagery as treated here.

TABLE 4. Regression Equations

I. Simple Linear Regressions of Factors (X) on Vegetation $Y(\bar{Y} = 4.29)$.

$\hat{Y}$	=	a	±	b	X	S.E.E.	r^2
Vegetation		8.40	-	.0025	elevation	.197	.167
"	=	3.94	+	.067	micro aspect	.215	.008
"	=	3.97	+	.067	local aspect	.216	.006
"	=	5.693	-	.031	slope angle	.209	.063
"	=	4.056	+	.049	across shape	.216	.002
"	=	2.636	+	.299	micro position	.200	.141
"	=	1.813	+	.425	local position	.197	.171
"	=	3.952	+	.806	soil water supply	.199	.152

II. Simple Linear Regressions of Factors (X) on Vegetation (Y) Transformed.

$\hat{Y}$	=	a	±	b	X	S.E.E.	r^2
Vegetation	=	34.751	-	9.497	$\log_{10}$ elevation	.196	.174
"	=	3.881	+	.645	$\log_{10}$ micro aspect	.215	.009

III. Multiple Regressions of Simple and Transformed Factors (X) on Vegetation (Y)

$\hat{Y}$	=	a	±	b_1X_1	b_2X_2	S.E.E.	R^2
Vegetation	=	5.162	-	.564 local aspect	+.0639 local aspect^2	.214	.034
"	=	4.409	-	.379 micro position	+.007 micro position^3	.179	.244
"	=	3.512	-	.124 local position	+.0056 local position^3	.194	.207

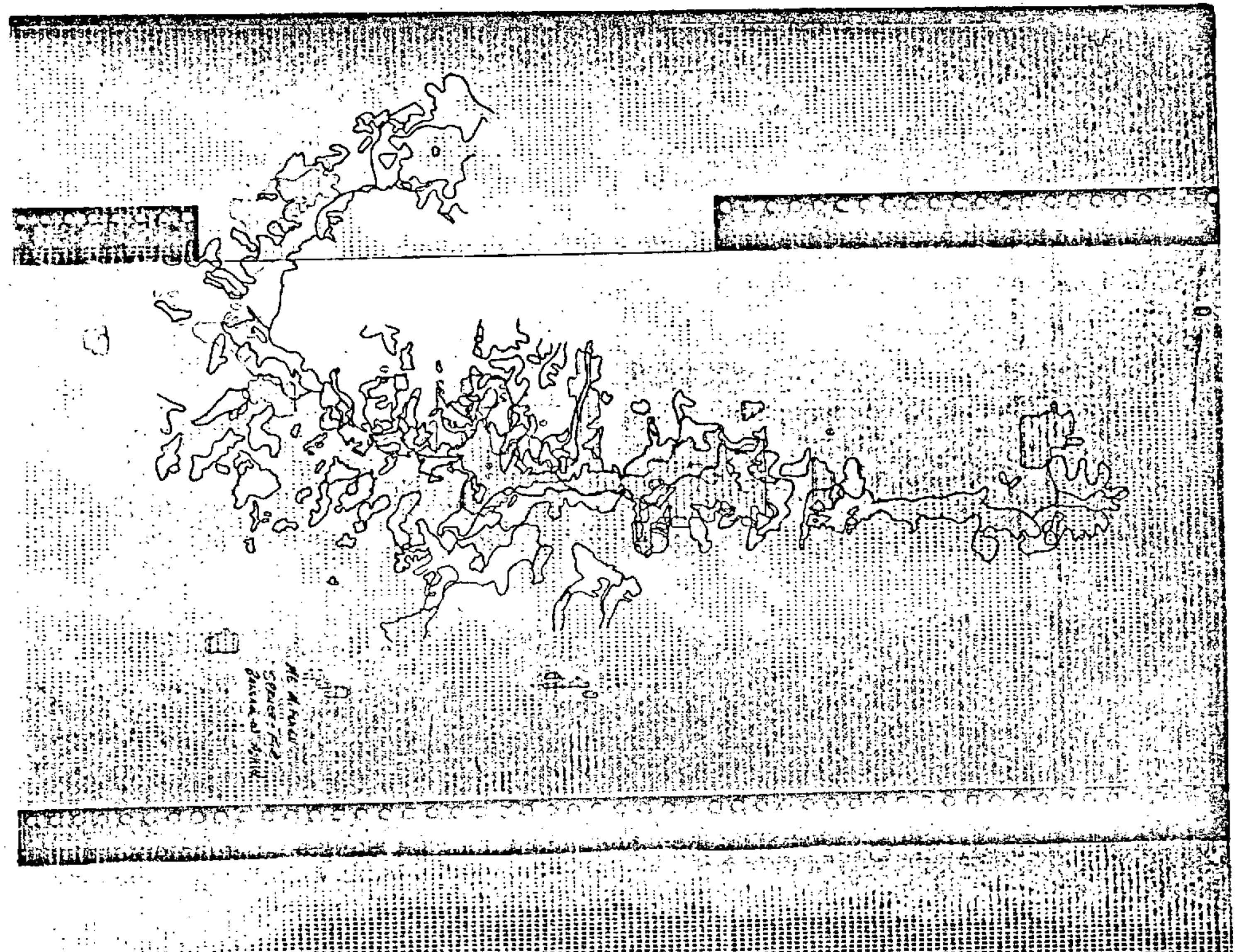

Figure 15. Overlay of fir mortality classes on Mount Mitchell area micro-densitometer printout.

Table 5. Percentages distribution on density scales of oak and hemlock vegetation on bands 4-7.

BAND 4

Density Scale	Oak	Hemlock
	- - -percent-	- - - -
111-113	--	--
114-116	--	--
117-119	--	--
120-122	--	--
123-125	.01	--
126-128	.16	.03
129-132	.37	.12
133-135	.19	.23
136-138	.18	.15
>138	.09	.47

BAND 5

Density Scale	Oak	Hemlock
	- - - percent-	- - - -
116-120	.02	---
121-126	.06	.03
127-131	.05	.03
132-137	.10	.02
138-142	.10	.03
143-148	.08	.10
149-153	.06	.02
154-159	.10	.05
160-164	.12	.11
>164	.31	.61

BAND 6

Density Scale	Oak	Hemlock
	- - -percent-	- - - -
71-75	.04	--
76-80	.06	--
81-86	.09	.01
87-91	.08	.03
92-97	.12	.05
98-103	.11	.03
104-108	.12	.08
109-113	.07	.10
114-119	.07	.18
>119	.23	.52

BAND 7

Density Scale	Oak	Hemlock
	- - - - percent-	- - -
59-65	.08	---
66-73	.14	.05
74-81	.22	.16
82-90	.17	.24
91-98	.12	.12
99-106	.14	.12
107-115	.04	.07
116-123	.05	.09
124-131	.01	.02
>131	.03	.14

Comparison of Interfaces Derived from RB-57 Imagery:

Interfaces Derived from ERTS-1 Printout

RB-57 imagery, NASA Mission 197, dated 18 April, 1972, of the Big Creek area of Great Smoky Mountains National Park at a scale of 1:60,000 was examined. Apparent on it were hardwood, heath and mixed hardwood-heath vegetation interfaces. Certain boundaries were reproduced, their scale converted to 1:32,500 on an overlay and this was superimposed directly upon the printouts of the area which had previously been used (1084-15431-6; Table 6). It can be seen that the two types are moderately well separated in densities >138 and 129-132. Mixed stands which were thought to be intermediate apparently have unique characteristics as suggested by their lack of intermediatness in most densities. Percentage distribution with increasing density trends increases on heath and increase and then decrease in mixed and hardwood vegetation types.

Comparison of RB-57 derived boundaries with ERTS-1 derived boundaries on band 5 appears in Table 7. Again most mixed stands are not intermediate between their presumed parental types. At no portion of the density scale is one type profoundly set off from another. Trends of percentages decrease with increased density in the mixed type, and are bimodal in heath and hardwood types.

Comparison of RB-57 derived boundaries with ERTS-1 derived boundaries on band 6 appears in Table 8. Clearly band 6 does not distinguish these types clearly. Mixed hardwood types are more or less bimodal with respect to relative distribution of percentages. The mixed type is intermediate in three of six density classes.

Table 6. Percent distribution on density scale of heath, hardwood and mixed vegetation on band 4.

Density Scale	Heath	Mixed	Hardwood
	VEGETATION		
	- - - - - - - - - - - percent-	- - - - - - - - - - - - - -	
123-125	< 0.1	0.0	0.0
126-128	3.2	0.0	5.5
129-132	14.0	21.3	42.5
133-135	17.5	33.8	23.8
136-138	22.2	38.8	17.8
> 138	42.7	6.5	11.0

Table 7. Percent distribution of density classes of heath, mixed and hardwood vegetation on band 5.

Density Scale	VEGETATION		
	Heath	Mixed	Hardwood
	- - - - - - - - - - -	percent - - - - - - - - - - -	- - - - - - - - - - -
138-142	20.3	30.0	27.1
143-148	18.3	35.7	19.9
149-153	9.0	10.0	10.7
154-159	14.6	16.4	13.2
160-164	10.7	2.1	4.1
> 164	27.0	5.7	25.6

Table 8. Percent distribution of density classes of heath, mixed and hardwood vegetation on band 6.

	VEGETATION		
Density Scale	Heath	Mixed	Hardwood
	- - - - - - - - - - -	-percent-	- - - - - - - - - - - - - - -
92-97	16.6	28.4	15.8
98-102	10.8	15.8	25.3
103-108	12.6	19.3	21.5
109-113	14.8	20.5	6.5
114-119	16.6	8.0	6.5
> 119	28.5	9.1	25.2

Comparison of RB-57 derived boundaries with ERTS-1 derived boundaries on band 7 appears in Table 9. Except between densities 99-115 in the mixed type, density percentage trends decrease with increased density. The mixed type is intermediate in about three of six density classes between the supposed parental types.

These data may be summarized in a different form. In Table 10 the percent data from previous tables was apportioned among arbitrarily chosen density classes of 10 units. Within each column the percents summed to 100. Each value was divided by 1200 to produce the between vegetation and band percentage comparison. Note that none of the vegetation types falls out alone in density class-band combination suggesting that ERTS-1 derived data of this type, treated as above, cannot be used to distinguish nor to delineate these types. The regular occurrence of the bands in certain density classes suggests that the mechanics of imagery manufacture is the chief factor in band density class representation.

Comparison of the Spruce-Fir Boundary: ERTS-1 Derived Printout and the 1:24,000 Map

A copy of the distribution of the spruce-fir forest in the Great Smoky Mountains National Park was transferred from a map at 1:24,000 to an overlay at a scale of 1:32,000. The overlay was compared directly to microdensitometer printouts (1084-15431-6) of the same area at the same scale (Table 11).

Most bands exhibit downward percentage trends from agreement through commission to omission errors. Errors of omission are variable but low; errors of commission are systematically higher with greater wavelength. This apparently reflects the greater density range per symbol; these increase with wavelength. Agreement is best on band 5. In mid-October high elevation

Table 9. Percent distribution of density classes of heath, mixed and hardwood vegetation on band 7.

Density Scale	VEGETATION Heath	Mixed	Hardwood
	-----------	percent-	---------------
91-98	28.3	41.0	58.8
99-106	29.9	13.1	26.5
107-115	16.3	26.2	14.7
116-123	12.0	9.8	0.0
124-131	4.9	4.9	0.0
> 131	8.7	4.9	0.0

Table 10. Relative distribution of ERTS-1 derived microdensitometer densities among vegetation types and bands.

Vegetation Bands	VEGETATION Heath				Mixed				Hardwood			
	percent											
Density	4	5	6	7	4	5	6	7	4	5	6	7
91-100			1.9	3.1			3.1	5.6			2.5	3.7
101-110			2.0	2.3			2.8	2.1			2.9	1.7
111-120			4.3	1.3			2.5	0.8			3.0	1.8
121-130	1.4			0.7	1.8				4.1			0.7
131-140	6.9	1.0		0.8	6.7	1.5			4.3	1.3		0.5
141-150		2.5				4.3				2.4		
151-160		1.8				1.8				2.1		
161-170		3.1				0.7				2.5		

Table 11. Percent agreement and error type. Comparison is between 1:24,000 scale spruce-fir map and ERTS microdensitometer printouts.

Band	Points Counted	Agreement	Commission	Omission
		- - - - - - - - - - - -	-percent - - - - - - - - - - - - -	
4	300	49.7	33.3	17.0
5	365	58.9	37.0	4.1
6	527	44.4	44.2	11.4
7	459	42.3	47.9	9.8

hardwood leaf color was yellow to brown and contrasted markedly with the green conifer vegetation. Agreement levels in this comparison in which a 1:24,000 base was used and those in which a 1:263,000 base was used are very similar (see later). The greater detail of the 1:24,000 base has apparently resulted in decreased errors of omission but increased errors of commission.

Comparison of the Spruce-Fir Boundary: ERTS-1 Derived Printout and the RB-57 Imagery

The first question that arises is what is represented on the ERTS-1 imagery (1084-15431-6); photographic copy in Figure 16. The darker central area is one of chief interest and it corresponds in general with land above 1372 m (4500 ft) elevation; it has lower air and soil temperatures and higher precipitation than is experienced on lower slopes. It seems possible that this represents the microthermal climatic regime found by Shanks in the high Smokies. However, the dark area does not appear on all ridges above 1372 m (4500 ft); for example, Thomas Divide does not appear dark - nor does this ridge possess the spruce-fir vegetation which caps most crests.

Comparison of Figures 16 and 17 suggests a general relationship between the extent of spruce-fir and the dark area. The area "S" on Figure 17 is a sketch of the boundary of spruce-fir forest but includes small bodies of other vegetation. It was prepared from 1:60,000 scale NASA RB-57 imagery, obtained April 1972. Differences in scale and skew in imagery make direct comparisons difficult. However, more feasible comparisons may be made by scanning the imagery (Figure 18). The larger scale printout is of a scale similar to that of the RB-57 imagery, as well as those of our base and vegetation maps. It is apparent that density levels greater than

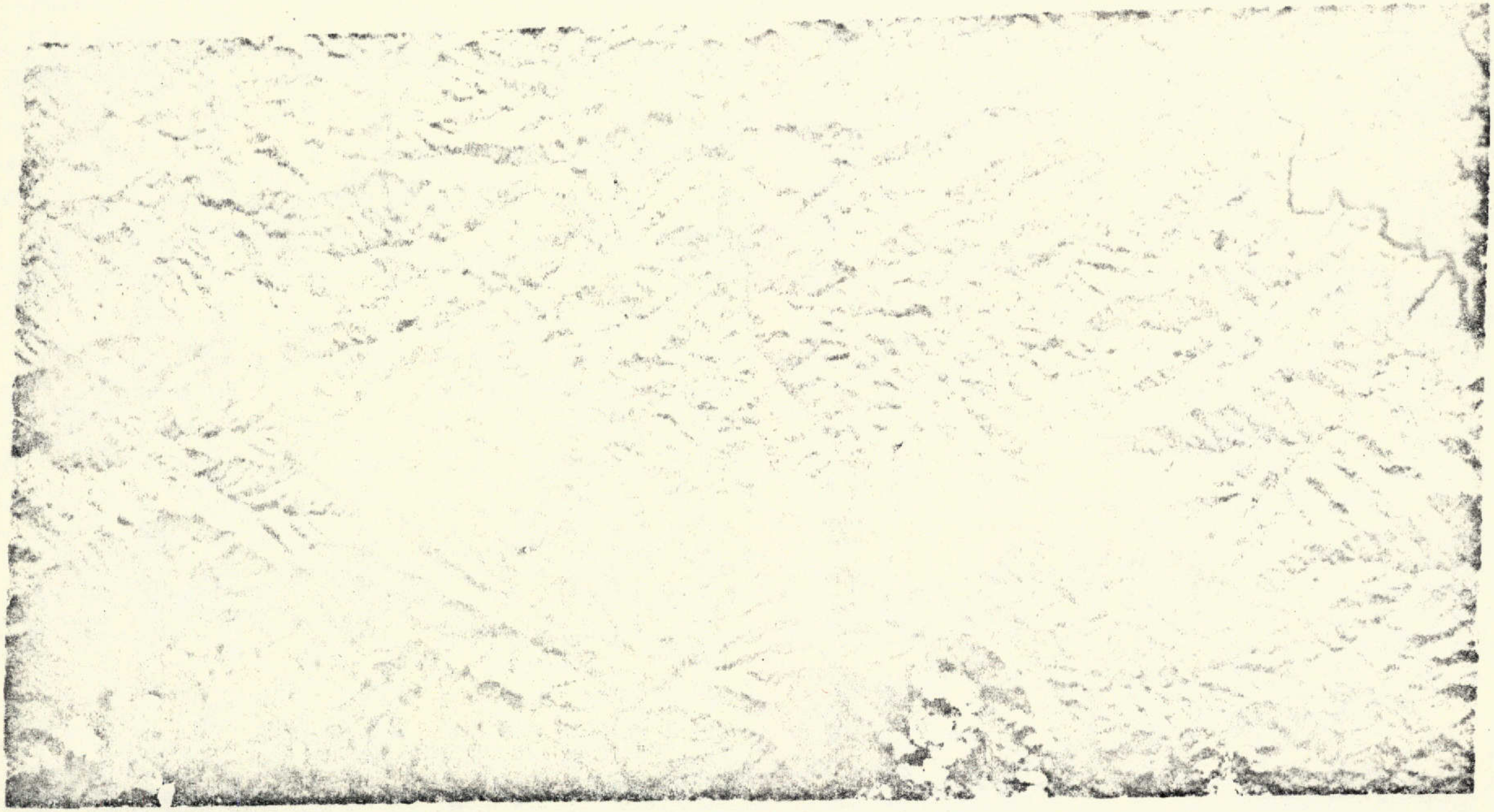

Figure 16. Photographic positive copy of ERTS-1 imagery of 15 October 1972 over the crest of the Great Smoky Mountains. North is lower left.

Figure 17. Sketch of boundary of mountain crest area chiefly in spruce forest (S). Big Creek valley is also outlined (V).

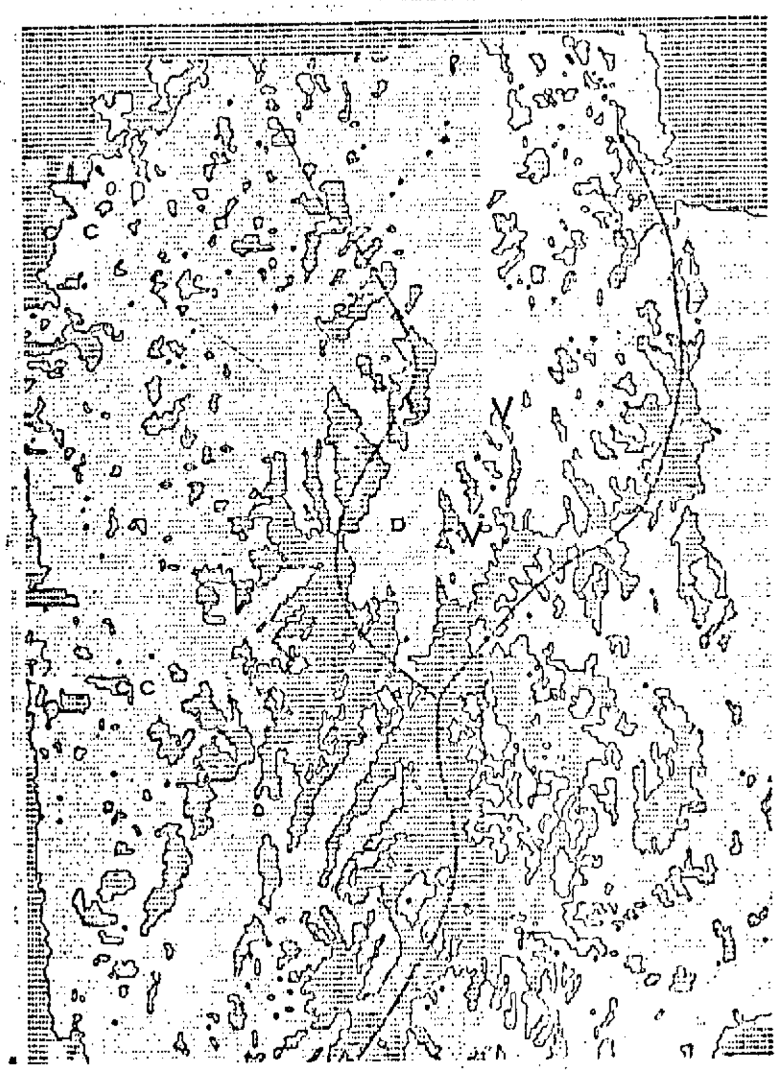

Figure 18. Printout of microdensitometer scan of the original of which Figure 16 was derived. Clouds and their shadows (C), Big Creek valley (V), and small valleys (D) appear. The main dark area is spruce forest. The highest ridges are shown as a heavy line.

107 (Θ and denser symbols) approximates spruce-fir forest although certain areas mapped as continuous boreal forest are here discontinuous and the reverse is also true. Types appeared to exhibit density ranges as suggested in Table 12.

Clouds and their shadows appear (Fig. 18). Large valleys (V on Figs. 17 and 18) simulate spruce. Small valleys are often represented by X (densities 91-98) near hardwood forest peaks. However, the agreement between the spruce area is mapped and that with densities $>$107 is relatively high (Table 13).

Density Range

Vegetation	58-65	66-73	74-81	82-90	91-98	99-106	107-132	133-156	157-256
Spruce-Fir	0.0	0.0	0.0	0.9	2.6	7.0	11.3	7.0	6.1
Spruce-Hardwoods	0.0	0.0	0.0	0.0	0.9	6.1	8.7	3.5	0.9
Hardwoods	2.6	6.1	2.6	1.7	0.9	0.0	5.2	0.0	0.0

Table 12. Comparison of microdensitometer print out density scale division groups and vegetation types on RB-57 imagery.

Table 13. Relation in percent of map and printout agreement by band number.

Band	Point Number	Agreement	Commission	Omission
		- - - - - - - - - - - - percent-	- - - - - - - - - - - - - -	
4	2495	50.0	29.5	20.5
5	2378	44.6	33.6	21.7
6	data similar to band 7			
7	681	64.6	14.7	20.7

CONCLUSIONS

Of the first two of the four major objectives sought by this project (to use winter evergreen plant chlorosis to define communities' interfaces, and to use particular colors in vegetation during spring phenologic development to define hardwood stands), we can say this: Imagery was neither of sufficient quantity--too often cloud covered--during the critical periods, nor of large enough scale to determine the feasibility of these methods of interface delimitation.

Evidence of attack of balsam wooly aphid on fir and of pine beetle on various southern pines was sought in East Tennessee and Great Smoky Mountains imagery without success. Comparison of the map of extensive aphid damage to fir on Mt. Mitchell was made with a microdensitometer printout of good imagery of this area (see "Results") but imagery did not reveal damage.

The body of the study was carried out using imagery of the Cumberland Mountains, Great Valley and Great Smoky Mountains of East Tennessee-Western North Carolina. Using the best overall imagery many topographic, geologic and land-use features are visible. On scene-corrected imagery the location of many features is map accurate but ridge-valley size is influenced by forest area and sun angle effects on warmed versus cooler slope aspects.

A legend system for land use annotation has been devised for the study area. Considerably more time would have to be invested to provide descriptors in all necessary units and to tabulate resources of even a small sample area. Since this was not an objective of the study, it has not been carried further.

Efforts to distinguish pine and/or cedar versus hardwood vegetation known at various scales in the three types of study areas using microdensitometer printouts of the best imagery have met with poor success: Wilson Mountain, Morgan County Study, Mascot Quadrangle, Principal Forest Types, Oak Ridge National Laboratory, Little River multistage comparison, Chilhowee Mountain, and also those in the Great Smoky Mountains. The hemlock-oak boundary and hardwood-heath boundaries were not well separated.

Various factors contribute to this. These are topographic--much of the topography of the area is in smaller units than that seen by one to a few MSS scan points or microdensitometer scan points. Vegetation types change with topography. Sun angle, aspect, and shading influence density in rough topography simulating vegetation change. Much "pine", etc., vegetation is actually pine-hardwood vegetation surrounded by hardwoods; the spectral differences are not as great as suggested by the names. Only a few ca. 4-5 good, cloud-free images were received from the 19 months of imagery. They were few enough that "cyclic" and "changing" ecological phenomena as read in the title of the proposal could not be investigated.

The crest of the Great Smokies, with its distinctive temperature and rainfall regimes on the one hand, and its unique vegetation on the other hand, was distinguished by the 15 October, 1972, imagery with 20.7 percent omission and 14.7 percent commission errors on band 7.

Orbital satellites using progressively more refined scanners or astronaut- or parachute-delivered photographic imagery offer outstanding possibilities to see and monitor the earth's resources. Research programs which compare imagery with ground truth are basic to planning and use of such facilities.

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APPENDIX I:

Relation of Imagery to Forest Characteristics

Valuable characteristics of commercial forests include volume and growth increment of sound wood. These data are collected by the U.S. Forest Service and the Tennessee Valley Authority locally at few (ca. five) year intervals. Bole diameter (Table 14) and height may be predicted from large scale imagery and wood volume data is calculated. Predictions using very small scale imagery have not proved successful (Aldrich, 1971).

The present project was likewise unable to find image characteristics which could be used to predict standing or incremental volume.

Table 14. Equations predicting bole dbh (inches) from crown diameter (feet).

	Y = a + bX	$\bar{Y}$ ∓ S.E.E.	r^2	N
Acer rubrum	-5.08 + .65X	21.52 ∓ 7.42	+0.55	71
A. saccharum	-10.17 + .87X	26.50 ∓ 6.30	0.56	30
Aesculus octandra	4.56 + .48X	22.80 ∓ 7.18	0.11	14
Betula lenta	0.47 + .56X	21.26 ∓ 6.47	0.37	38
B. lutea	5.57 + .29X	15.78 ∓ 5.81	0.19	42
B. nigra	0.93 - .47X	15.40 ∓ 2.78	0.90	5
Fagus grandifolia	-5.44 + .60X	17.00 ∓ 10.11	0.22	30
Fraxinus americana	-1.13 + .42X	13.33 ∓ 2.42	0.74	6
Halesia monticola	0.18 + .51X	16.44 ∓ 5.61	0.15	32
Liriodendron tulipifera	-0.87 + .58X	19.69 ∓ 6.98	0.41	39
Magnolia acuminata	-0.38 + .50X	15.60 ∓ 5.51	0.18	4
M. fraseri	-7.77 + .70X	13.23 ∓ 5.68	0.71	13
Nyssa sylvatia	-1.41 + .47X	14.78 ∓ 3.58	0.52	9
Oxydendron arboreum	3.50 + .18X	6.67 ∓ 2.33	0.19	9
Picea rubens	4.37 + .55X	22.55 ∓ 6.30	0.13	69
Pinus rigida	6.09 + .28X	13.09 ∓ 1.69	0.38	11
Prunus pensylvanica	1.23 + .51X	12.40 ∓ 2.96	0.44	5
Quercus coccinea	2.00 + .32X	10.00 ∓ 4.25	0.02	6
Q. montana	-12.66 + .82X	18.53 ∓ 5.41	0.77	17
Q. rubra	-9.41 + .77X	25.86 ∓ 7.59	0.34	97
Robinia pseudo-acacia	7.54 + .27X	16.76 ∓ 6.07	0.18	21
Sassafras albidum	2.00 + .33X	2.50	1.00	2
Tilia heterophylla	-0.56 + .64X	24.89 ∓ 13.10	0.15	18
Tsuga canadensis	2.51 + .56X	23.02 ∓ 9.12	0.37	45

APPENDIX II:

Descriptor Forms

The following image descriptor forms complete the examination and reporting on all imagery received on the contract.

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ERTS IMAGE DESCRIPTOR FORM

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PRINCIPAL INVESTIGATOR H.R. DeSelm

~~XXXX~~ GSFC USER ID: UN 598

~~XXXXXXXXXXXX~~ ORGANIZATION University of Tennessee-Knoxville

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1201 15441 bands 4-7 80% clouds				clouds
1211 15493 band 6 no clouds				valleys, agriculture, mountains, rivers, forest, reservoirs
1212 15554 bands 4-7 90% clouds				clouds
1227 15381 bands 4-7 90% clouds				clouds
1227 15375 bands 4-7 70% clouds				clouds, forest, mountains
1228 15442 bands 4-7 80% clouds				clouds
1228 15440 bands 4-7 30% clouds				valleys, agriculture, mountains, rivers, forest, reservoirs
1229 15494 bands 4-7 80% clouds				rivers
1229 15501 bands 4-7 90% clouds				clouds

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1247 15495 bands 4-7 99% clouds				clouds
1247 15501 bands 4-7 95% clouds				clouds
1263 15384 bands 4-7 40% clouds				forest vs. agriculture rivers reservoirs
1263 15382 bands 4-7 60% clouds				clouds
1264 15440 bands 4-7 70% clouds				clouds
1264 15443 bands 4-7 clear				mountains valleys forest agriculture rivers reservoirs
1265 15494 bands 4-7 clear				mountains valleys forest agriculture rivers reservoirs
1265 15501 bands 4-7 clear				mountains valleys forest reservoirs rivers agriculture
1266 15555 bands 4-7 30% clouds				mountains valleys forest agriculture rivers reservoirs

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1281 15383 bands 4-7 15% clouds				mountains valleys forest agriculture rivers reservoirs
1281 15381 bands 4-7 70% clouds				forest fields
1282 15442 bands 4-7 100% clouds				clouds
1282 15435 bands 4-7 15% clouds				mountains valleys forest agriculture rivers reservoirs roads strip mines
1284 15555 bands 4-7 95% clouds				clouds
1263 15382 bands 4-7 90% clouds				clouds
1263 15384 bands 4-7 40% clouds				forest agriculture rivers reservoirs
1299 15380 bands 4-7 1% clouds				forest agriculture mountains valleys rivers reservoirs roads strip mines

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1299 15383 bands 4-7 no clouds				forest agriculture mountains valley rivers reservoirs strip mines roads
1300 15434 bands 4-7 80% clouds				rivers reservoirs mountains valleys forest agriculture roads
1300 15441 bands 4-7 80% clouds				rivers reservoirs forest agriculture
1302 15554 bands 4-7 1% clouds				rivers reservoir mountains valleys forest agriculture roads
1317 15381 bands 4-7 90% clouds				clouds river reservoir
1317 15375 bands 4-7 80% clouds				clouds roads mountains valleys forest agriculture
1319 15494 bands 4-7 95% clouds				clouds reservoirs
1319 15492 bands 4-7 60% clouds				rivers reservoirs forest agriculture

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1335 15380 bands 4-7 50% clouds				forest agriculture rivers reservoirs
1335 15374 bands 4-7 50% clouds				forest agriculture roads
1335 15371 bands 4-7 70% clouds				rivers reservoirs
1336 15434 bands 4-7 30% clouds				forest agriculture roads mountains valleys river reservoir
1336 15432 bands 4-7 80% clouds, haze				mountain valley river reservoir roads strips forest agriculture
1337 15493 bands 4-7 50% clouds				" "
1337 15490 bands 4-7 15% clouds, haze				" "
1354 15431 bands 4-7 5% clouds				" "

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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~~GSFC~~ USER ID: 598

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1355 15492 bands 4-7 60% clouds				mountain valley river reservoir roads strips forest agriculture
1355 15485 bands 4-7 30% clouds				" "
1354 15433 bands 4-7 20% clouds				" "
1371 15373 bands 4-7 1% clouds				" "
1371 15364 bands 4-7 90% clouds				rivers
1371 15371 bands 4-7 30% clouds				rivers reservoirs mountains valleys forest agriculture roads strips
1372 15432 bands 4-7 40% clouds				" "
1372 15425 bands 4-7 80% clouds, haze				mountains valleys forest agriculture rivers roads strips
1372 15425 bands 4-7 90% clouds, haze				rivers reservoirs mountains valleys forest agriculture

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~~GSFC~~ USER ID: 598

~~ORGANIZATION~~

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS	
1389 15372 bands 4-7 40% clouds				rivers mountains forest	reservoirs valleys agriculture
1389 15365 bands 4-7 30% clouds				"	"
1389 15363 bands 4-7 80% clouds				forest	agriculture
1391 15482 bands 4-7 40% clouds				rivers mountains forest	reservoirs valleys agriculture
1391 15485 bands 4-7 95% clouds				clouds	
1391 15482 bands 4-7 70% clouds				rivers forest	reservoirs agriculture
1407 15364 bands 4-7 2% clouds				rivers forest mountains roads	reservoirs agriculture valleys
1407 15370 bands 4-7 no clouds				"	"
1407 15361 bands 4-7 no clouds				"	"

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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DATE 14 March 1974

PRINCIPAL INVESTIGATOR H.R. DeSelm

~~GSFC~~ USER ID: 598

~~ORGANIZATION~~

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1408 15424 bands 4-7 20% clouds				rivers, forests, mountains, roads, reservoirs, agriculture, valleys
1408 15422 bands 4-7 10% clouds; 100% haze				" "
1409 15480 bands 4-7 100% clouds				clouds
1409 15483 bands 4-7 100% clouds, haze				clouds
1425 15361 bands 4-7 100% clouds				clouds
1425 15364 bands 4-7 15% clouds				forests, river, road, agriculture, reservoirs
1425 15361 bands 4-7 95% clouds				clouds
1426 15422 bands 4-7 90% clouds				clouds
1426 15415 bands 4-7 75% clouds				forests, river, mountains, road, agriculture, reservoirs, valleys

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO
ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

ERTS IMAGE DESCRIPTOR FORM

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DATE 14 March, 1974

PRINCIPAL INVESTIGATOR H.R. DeSelm

~~GSFC~~ USER ID: 598

~~ORGANIZATION~~

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1427 15480 bands 4-7 80% clouds				rivers reservoirs forest agriculture
1427 15474 bands 4, 6, 7 15% clouds				rivers roads reservoirs forest agriculture mountains valley
1427 15480 bands 4-7 70% clouds				river reservoir forest agriculture
1427 15474 bands 4-7 60% clouds				" "
1425 15364 bands 4-7 20% clouds				mountains valleys rivers roads reservoirs forest agriculture
1428 15534 bands 4-7 40% clouds				" "
1443 15354 bands 4-7 80% clouds				" "
1443 15352 bands 4-7 100% clouds				clouds
1443 15361 bands 4-7 20% clouds				mountains valleys rivers roads reservoirs forest agriculture

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO
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GSFC 37-2 (7/72)

ERTS IMAGE DESCRIPTOR FORM

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1444 15415 bands 4-7 20% clouds				mountains valleys rivers roads reservoirs forest agriculture
1444 15412 bands 4-7 40% clouds				" "
1445 15473 bands 4-7 60% clouds				" "
1445 15471 bands 4-7 50% clouds				" "
1446 15531 bands 4-7 10% clouds				mountain valley rivers reservoirs forests agriculture

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
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GSFC 37-2 (7/72)

APPENDIX III:

Publicity and Papers

A. Publicity and seminar-type talks:

1. Article, February, 1973, Maryville-Alcoa Times.

2. U.T. Botany Department Seminar talk, 13 February, 1973.

3. Knoxville Science Club talk, 1 March, 1974.

4. NASA Discipline Panel Review, 26 October, 1973.

B. Scientific audience addresses, abstract published:

DeSelm, H.R., C.C. Amundsen, P.F. Krumpe, T.W. Taylor. 1972. Inferences from remote sensing of forest landscape. The A.S.B. Bull. 19(2): 65 (abstract).

Golden, M.S. and H.R. DeSelm. 1972. Forest vegetation—site relationships in the central portion of the Great Smoky Mountains National Park. Jour. Tenn. Acad. Sci. 47(2): 55 (abstract).

Golden, M.S. and H.R. DeSelm. 1972. Relating forest vegetation to site characteristics in the Central Great Smoky Mountains. The A.S.B. Bull. 19(2): 71 (abstract).

DeSelm, H.R. 1973. Ecological applications of ERTS-A imagery. IEEE Trans. Geoscience Electronics 11(1): 17 (abstract).

Taylor, T.W., B.F. Clark, Jr., and H.R. DeSelm. 1973. Multiband remote sensing of vegetation boundaries in the Great Smoky Mountains National Park. The A.S.B. Bull. 20(2): 86 (abstract).

C. Scientific papers published:

DeSelm, H.R., C.C. Amundsen, P.F. Krumpe. 1972. Prediction of site and cover parameters. Proc. Tenth I.E.E.E. Conf.: pp. M3-1 through M3-4. Knoxville, Tennessee.

DeSelm, H.R., C.C. Amundsen, P.F. Krumpe. 1972. Remote sensing of the Appalachian wildland resources. Proc. Conf. Earth Resources Observation and Information Analysis System. March 13-14, 1972. University of Tennessee Space Institute, Tullahoma. Remote Sensing of Earth Resources I: 193-205.

DeSelm, H.R. and T.W. Taylor. 1973. Vegetation boundaries on ERTS-1 imagery. Proc. Second Annual Remote Sensing of Earth Resources Conference. 2: 925-933.